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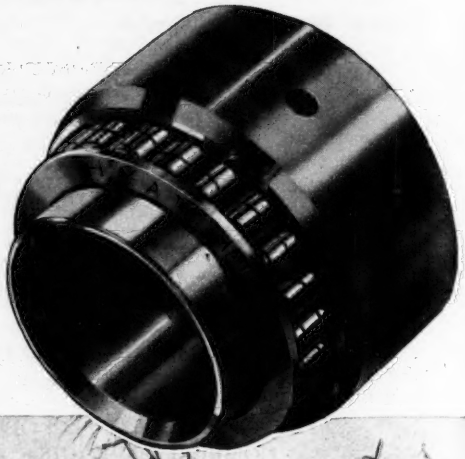

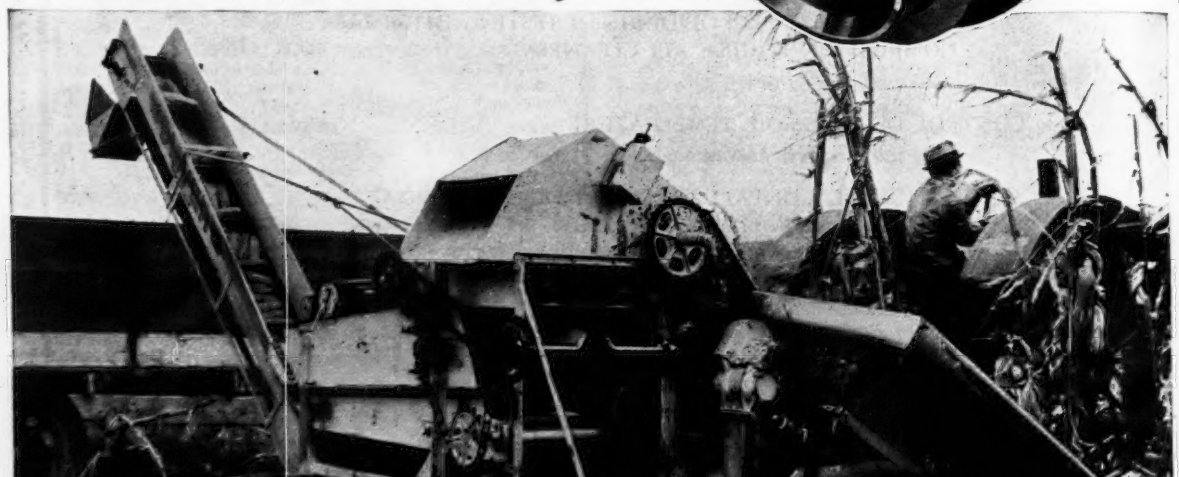

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AGRICULTURAL ENGINEERING

VOL 17, NO 9 EDITORIALS SEPTEMBER 1936

Some Thoughts on Upstream Engineering

BY WAY of priming the mental pump for the forthcoming Upstream Engineering Conference at Washington this month, what of the proposed consolidation of information and organization for action?

Papers, addresses, and discussions as scheduled will bring together a mass of technical data, viewpoints, and problems with much of which agricultural engineers are already familiar. To the uninitiated this will indicate the surprising complexity of upstream engineering and the magnitude of its unsolved problems. To agricultural engineers and others experienced in upstream engineering, it will provide material for a pattern to be pieced together to show the problem as a whole, with its many phases in rational relationship.

Upstream engineering problems are as local and individual as a hillbilly clan. Their solutions must be custom-built, based upon knowledge of the precipitation, area, slope, soil, subsoil, percolation, vegetation, land use, evaporation, irrigation, ground water, drainage, runoff and other characteristics of the watershed in question.

Increasing knowledge of these factors being gained by patient research can be and is being charted into a growing hydrographic foundation for all upstream engineering. The Conference will necessarily contribute something to this foundation, and may by forethought sponsor further needed research in this direction.

C. E. Ramser's paper on watershed and hydrologic studies, published elsewhere in this issue, presents an excellent outline of a project to obtain some of this basic knowledge.

A further step in the consolidation of information would naturally be the cataloguing of engineering technique and equipment for both research and practice, with their characteristics, limitations, and applicability to various watershed characteristics.

With their facts thus organized, engineers will be in a position to begin evaluating their current practices and tentative conclusions; to agree on their major problems and the weak points in their technical set-up for attacking those problems; to plan and support upstream engineering research with a united front; to meet current flood and erosion emergencies with increasingly effective and efficient stopgap engineering, based on the best knowledge and facilities available; to carry on with an equitable division of functions, keeping their information organized as they go.

This organization of facts will not evolve during the Conference and be ready to hand out at the door when the final session ends. Little more can be expected of the Conference than to initiate and draw public attention to the need of action. Much subsequent collaboration will be necessary to correlate existing knowledge of the field into a more workable science.

Upstream engineering, under its older names of soil and water conservation, drainage, irrigation, reclamation, and flood control, is an old subject, and a big one. The marshalling of its forces is timely.

Agricultural engineers will do well to attend the Conference, not expecting to be greatly enriched with surprising new knowledge on the subject from other branches of engineering, but mentally primed to urge effective organization to consolidate existing information in the field into one purposeful, applicable, economically valuable science.

AEC on the Straight and Narrow

AMERICA is fortunate in the concepts of service to which the American Engineering Council has held doggedly for the sixteen years of its organized life.

The engineering development which has grown from political, economic, and educational democracy reaches into the everyday lives and interests of all Americans and of their government. It creates problems in public understanding, policy, and action.

A desirable intermediary between public interest, private industry, and engineering possibility must, first of all, recognize the public's interest as identical with its own. It must earn and deserve public confidence and respect.

And, in the words of George H. Shepard, professor of industrial engineering and management at Purdue University, commenting in "Mechanical Engineering" for September, "If engineers express themselves with a reasonable degree of tact, they will be heeded. They must be careful however to avoid an air of superior wisdom; and above all, they must not give the impression that they are seeking to make themselves a ruling caste—'technocrats' in the catch phrase of yesteryear."

It needs to promote "clear thinking by engineers on public questions"; "right thinking from an engineering, economic, and sociological standpoint"; to accomplish "the factual analysis of engineering-economic problems." It should bring to light "the predominance of resulting engineering opinion," and act thereon, not in a managing, but in an advisory capacity.

Its value as an intermediary is limited by the extent to which it remains nonpartisan, unbiased, and unmoved by anything but opportunity to serve the public good.

Its ethical creed must be to seek, dispense, and support the truths which the engineering-born complexities of modern economic and social organization have tended to obscure.

It must effect a representative organization of organizations of engineers to present a united front in spreading the knowledge of principles and policies established as guides to intelligent public opinion and governmental action. It must "unify the engineering profession in viewpoint, thought, and action without interfering with the specialized fields or with the autonomy of its member engineering societies."

This is the situation, these are the concepts, and such is the organization of American Engineering Council which make it a growing force for mutual public and engineering understanding and welfare.

Engineering Problems of Molecule Farming

AN INDEX to the work for agricultural engineers in the farm chemurgic movement may be gleaned from a review of the proceedings of the Second Dearborn Conference of Agriculture, Industry, and Science.

It shows an intensive and extensive chemical reconnaissance being made into the possibilities of farm products as raw materials for manufacturing industries. It shows fingers of industrial development reaching out in directions shown promising.

It looks to agricultural scientists to define and develop biological possibilities as to variety, quantity, quality, purity, and uniformity of the biological products it would use.

It looks to whoever may be able to do the job, to reduce costs of these chemically potent raw materials to within range of quantity production and marketing.

The implication to agricultural engineers, to continue their normal work of improving standard production and harvesting equipment and methods for lowering the cost of producing standard farm crops, is obvious. Less obvious, newer implications for agricultural engineers to aid chemurgic progress call for further consideration, lest opportunities be overlooked and agricultural engineers be guilty of crimes of omission.

Agricultural scientists introducing and developing such new crops as tung, perilla, Chinawood, pyrethrum, and Jerusalem artichokes can well use agricultural engineering consultation as to production cost, handling, and storage factors influencing their ultimate practicability as farm crops for specific areas and conditions. Likewise in the improvement by breeding of such staple crops as corn, cotton, and soybeans to meet quality and cost specifications for manufacturing purposes.

Farmers pioneering in the commercial production of new or improved crops will call for advise on their new engineering problems.

New and modified field and storage equipment will be required.

The industrial bid for supplies of complex organic molecules in usable forms and concentrations, at quantity production prices, may easily lead in some cases to preliminary processing on farms. These would include operations which could be performed with comparatively few, simple, and inexpensive machines not requiring expert control, or controlled partly by automatic devices.

They might be applied to separating operations, to enable the farmer to ship the component oil-bearing, protein, starch, sugar, fibrous, or other parts of his crop to separate specialized processing plants. They might be applied to cleaning and concentrating operations to avoid shipment and factory handling of excess weight and bulk of water, dirt and fibrous waste. They might be applied to preserving operations, to put perishable molecules into more stable forms for shipment and storage pending final processing.

It can scarcely be called visionary to consider the possibility of farmers finding profitable winter work on their own farms in turning their corn, straw, potatoes or whatnot into pulps, syrups, ferments, or flours for shipment to processing plants. The equipment and its operation on the farm would become agricultural engineering problems.

A similar possibility would be initial processing by producer cooperatives at the shipping point, likewise involving problems of agricultural engineering technique within its ordinary service field.

Farm products "gone industrial" may in many cases create agricultural engineering problems and opportunities on the rebound; witness power alcohol, pyrethrum insecticides and organo-phosphate fertilizers.

Biological possibilities for intensified and specialized production of proteins, carbohydrates, and oils; chemical possibilities for their use to produce new plastics, paints, papers, fabrics, starches, sugars, cellulose compounds, insecticides, fertilizers, alcohols and other chemicals by the thousands; the economic and engineering feasibility of their uses in industry, all depend for commercial realization, on proof of ability to lay down at the processing plant the farm-produced organic molecules at sufficiently low cost and with a profit to the farmer that will insure dependable supply. And that ability largely involves problems of agricultural engineering feasibility.

Engineering at the Shipping Point

HOW FAR beyond the farm and toward the consumer can agricultural engineers extend their services? The question is brought up by the report, elsewhere in this issue, of agricultural engineering investigations of fruit precooling in railroad cars before shipment.

Engineering aids to handling, processing, storage operations, and environmental condition control of farm products on the farm are obviously agricultural engineering matters. They involve cooperation with crop, marketing, economic, and other specialists as to limiting and optimum conditions to be met. Training and experience in the technique of meeting these requirements on the farm develop a specialized ability to met them under similar conditions, though somewhat removed from the farm.

The refrigerator car box is similar in size, shape, thermal conductivity, and ventilating characteristics to the order of storages on farms with which agricultural engineers are acquainted. From that standpoint the engineering of its use, to store and control the conditions of farm products in transit, is distinctly within the technical field of agricultural engineers.

It is also within the service field of agricultural engineering. Much of the perishable produce hauled in refrigerator cars is owned and shipped by individual farmers or producer cooperatives. Its condition at its destination is as vital to them as its cultivation and harvesting. And even where independent buyers and middlemen are the direct beneficiaries of improved shipping, it inevitably places competition for produce on a more profitable plane for the farmer.

What we have said of agricultural engineers working on precooling of perishables for transit in refrigerator cars, applies to all engineering problems at the farm shipping point. It is distinctly within the technical and service field of agricultural engineering to see farm products well on their way to market.

Watershed and Hydrologic Studies in Soil Conservation

By C. E. Ramser

OBJECTS of the studies to be conducted by the section of watershed and hydrologic studies of the Soil Conservation Service, U. S. Department of Agriculture, are as follows:

1 To determine the effect of erosion control practices and land use upon the conservation of water for agricultural purposes, such as irrigation and domestic farm supplies, and for public utility purposes, such as water power and urban water supplies.

2 To determine the effect of erosion control practices and land use upon the control of floods that destroy crops, damage soil fertility on agricultural bottom lands, and cause damage to or destruction of municipal property.

3 To determine the rates and amounts of runoff and eroded soil material from rains of different amounts and intensities, for use in the economic design of erosion control and flood control structures. This information will also be of value in determining to what extent eroded material can be prevented from entering, and reducing the capacity of drainage channels and reservoirs, by the application of proper land use and erosion control practices.

REASONS FOR STUDY

Practical reasons justifying the need for these studies, all of which involve substantial financial benefits to the country, are as follows:

I. CONSERVATION OF WATER

1 Crop losses experienced by farmers not only in the semihumid but also in the humid regions of the United States during the past year indicate the need of proper agricultural practices to conserve all available moisture for crops. Proper vegetative, tillage, and other methods of controlling erosion tend to conserve the moisture for crops, and it is essential that authentic information be collected, indicating to the farmer the effectiveness of these methods, in order to substantiate their adoption in a nation-wide water conservation program.

2 A knowledge of the effect of land use and erosion control practices upon both surface and underground water supply for municipal, irrigation, and other purposes, is important in a program designed to work out the proper relation between these uses and the consumption of water by plants on the watershed, which may in some cases be more or less conflicting. For instance, surface water supplies for cities often command first consideration, which demands that the watershed yielding the supply receive treatment conducive to the maximum yield consistent with land use. On the other hand, replenishment of the underground supply by proper treatment of the watershed, conducive to the maximum amount of percolation, may make available increased water supply from wells for municipal or irrigation purposes, which in the latter case would have no doubt resulted in untold benefits to the drought-stricken and wind-eroded areas during the past year. The results of these experiments will indicate the possibilities of utilizing to the best advantage all of the water falling on a watershed, thereby preventing wastage of a large part of this water in surface runoff through stream channels.

3 The effect upon the low water flow in streams resulting from proper treatment of the watersheds to increase percolation, and thereby the amount of water that reaches streams from underground sources, deserves a detailed and comprehensive study. Immense financial benefits would result to both navigation and water power projects in a better regulated and more uniform stream flow. For instance, the capital investment of a water power project is much less where uniform stream flow is available as compared with wide fluctuations, which in the latter case requires a large investment, either for storage facilities or for an auxiliary steam power plant to meet periods of low flow.

II. FLOOD CONTROL

1 One of the primary objects of flood control is to prevent the overflow of fertile bottom lands, with resulting injury or complete damage to crops. Floods also cause the destruction of valuable city property, and very often the loss of lives. For instance, the physical loss to property during the Dayton, Ohio, flood in 1913 was estimated at about $70,000,000. The extent to which the destructiveness of such floods can be ameliorated, by proper treatment of land on the watersheds, will be determined from careful and comprehensive studies. These studies will also show to what extent flood control improvements, such as levees, artificial channels, and retention basins, can be dispensed with, or to what extent the cost of such improvements can be reduced by proper land use and erosion control practices on the watershed.

2 Floods are usually attended by the movement of large amounts of silt in the flood waters. The final disposition of this silt is often inimical to the best interest of landowners and municipalities. (a) For example, heavy, coarse silt is often deposited over fertile bottom lands, rendering the land permanently unproductive where the deposit is deep, and, even where shallow, the productivity of the land is often appreciably reduced and the difficulty and cost of

GULLIES REACHING UP AN UNPROTECTED STEEP SLOPE

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Author: Senior soil conservationist in charge of watershed and hydraulic studies, Soil Conservation Service, U. S. Department of Agriculture. Mem. ASAE.

tilling the soil is increased. The fertility of large areas of rich bottom lands in the delta lands of the Mississippi River has been ruined by deposits of unfertile material from Mississippi floods. Numerous examples of serious damage to bottom lands in this way are quite common throughout the country. (b) Silt is often deposited in the channels of navigable streams, natural drainage channels, or dredge ditches. These channels must be cleaned out periodically, at great expense, in order to prevent floods or insure navigability. As an example, a large dredged outlet ditch of a drainage district in the Missouri River bottoms of eastern Nebraska was nearly filled in one season with sediment contributed by eighteen small, tributary, upland watersheds. This filling could no doubt have been greatly reduced or practically eliminated by proper agricultural treatment of the land on these watersheds. (c) The deposition of silt in reservoirs constructed at great expense for municipal, irrigation, or other purposes reduces their needed capacity, often resulting in a shortage of water during critical periods of the year, and a financial loss to the community. Examples of reservoirs throughout the country that have lost a considerable part of their capacity are too numerous to mention. Possibly one of the most outstanding illustrations is that of the reservoir created by Austin Dam in Texas that was nearly filled with sediment during a period of about fifteen years.

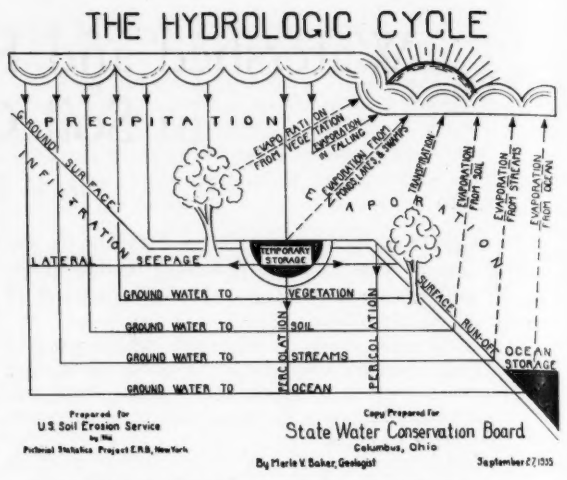
It hardly seems necessary to comment upon the vital need to study the effectiveness of treating watersheds by proper land use and erosion control practices, to produce a minimum yield of silt and thereby obviate the costly difficulties described above.

III. RATES AND AMOUNTS OF RUNOFF FROM WATERSHED AREAS

Accurate information relating to rates and amounts of runoff from watersheds is essential to the economic design of engineering structures for erosion control and flood control purposes. For instance, the satisfactory design of notches for check dams; spillways and drop-inlet culverts for soil-saving dams; channels and outlet ditches for terraces; and diversion ditches, all of which are used in erosion control work, depends upon reliable information on runoff. This information will also be available for use in the proper design of drainage channels, floodways, and reservoirs required in the planning of irrigation, water supply, water power, and flood control projects.

Structures of all kinds, whose design is based upon an inadequate knowledge of runoff from watersheds, may be unable to handle the runoff from heavy rains, resulting in damage to or total failure of the structures. On the other hand, if such structures have a much greater capacity than is required to take care of the runoff, then a financial burden is imposed corresponding to the cost of the surplus capacity. From this it is obvious that comprehensive studies are justified for the collection of accurate runoff data, in order that a financial saving may be effected through the most economic design of engineering structures. Costly failures of check dams due to inadequate notches, and of soil saving dams due to inadequate capacity of culverts or spillways, are of frequent occurrence throughout the country, all of which can be attributed to a lack of basic runoff data.

The problem consists of a detailed and comprehensive study of the action of water from the time it reaches the ground surface as precipitation, until it leaves the watershed as surface or underground flow, which will include studies of precipitation, percolation, evaporation, transpiration, surface and underground storage, and rate of movement over the ground surface and through stream channels.



THE HYDROLOGIC CYCLE GRAPHICALLY ILLUSTRATED. PICTURING MAIN FACTORS IN NATURAL BEHAVIOR OF WATER AND SUGGESTING POINTS FOR APPLICATION OF ENGINEERING CONTROL MEASURES

A more detailed outline of the factors to be considered and analyzed in the ultimate solution of the problem in their relation to runoff water conservation, and flood control is as follows:

1 Physical characteristics of watersheds
   (a) Soil and subsoil, including texture, structure, composition, and degree of saturation
   (b) Topography, that is, degree and length of slopes, and uniformity and regularity of ground surface across and along slopes
   (c) Physiography, including arrangement of drainage systems
   (d) Cover, that is, forest, pasture, and cultivated and other crops
   (e) Storage, that is, surface and underground
   (f) Artificial factors, that is, tillage practices and erosion control practices
   (g) Geological formation
2 Precipitation
   (a) Amount
   (b) Intensity
   (c) Duration
   (d) Distribution, that is, over watershed, and seasonal
3 Water disposal
   (a) Evaporation
   (b) Percolation, including groundwater reaching streams, and deep seepage, that is, water not appearing again in drainage channels of watershed
   (c) Interception and transpiration
   (d) Surface runoff

In addition to measurements and studies of the foregoing factors, continuous records will be kept and studies made of the direction and velocity of wind, humidity, air and soil temperatures, and atmospheric pressure.

The San Dimas watershed study, which was planned by Dr. W. C. Lowdermilk and is being conducted by the California Forest Experiment Station of the USDA Forest Service, is the most complete, detailed, and comprehensive study of this nature that has ever been undertaken. The San Dimas study relates to chaparral forest watersheds. Other important experiments relating principally to forest and herbaceous watersheds are the Emmenthal watershed experiment by Arnold Engler; the Wagon Wheel Gap experiment by C. G. Bates and A. J. Henry; the Great Basin experiment by C. L. Forsling. These studies will be patterned after the San Dimas study with necessary modifications to meet different conditions existing on agricultural lands.

Hydrologic investigations have been in progress at all of the ten soil erosion experiment stations of the Soil Conservation Service, on plots and small watersheds, and at

several of the stations lysimeter studies are being carried on. Also, studies are being conducted on a few large watersheds, one of which, near Pullman, Washington, has a drainage area of 18,000 acres. At several of the stations records of 5 years' duration have been obtained and have already been of value in their application to practical water conservation and erosion control problems.

Numerous runoff studies on agricultural lands have been made by the USDA Bureau of Agricultural Engineering, the most outstanding of which were conducted on the Murchison Farm near Jackson, Tennessee, and on Ralston Creek near Iowa City, Iowa. The experiments at Jackson, Tennessee, were of comparatively short duration and had for their primary object the collection of maximum rates of runoff together with coefficients of runoff for small agricultural areas applicable to the design of open-ditch drainage systems, terrace systems, diversion ditches, tile drains, and culverts. The experiments consist of making rainfall and runoff measurements on six small hilly watersheds ranging in area from 1¼ to 112 acres. The Ralston Creek rainfall and runoff studies were started in 1925 and are still being continued. They include rather complete studies on a single drainage basin of 3 square miles.

Runoff investigations have been conducted on many projects throughout the humid region of the United States by the drainage division of the Bureau of Agricultural Engineering on agricultural watershed areas ranging from ten to one hundred and more square miles. Outstanding among these were comprehensive investigations conducted near Urbana, Illinois, in cooperation with the University of Illinois, over a five-year period to collect runoff and hydraulic data for the design of dredged drainage channels.

The general plan of study includes (1) the evaluation of all important factors by carefully conducted experimental studies, and (2) tracing the operation of such factors from small to large watersheds.

The isolation and measurements of the effect of each particular factor influencing surface runoff and soil erosion is accomplished by tanks or lysimeters designed to measure rainfall of different intensities, durations, and amounts, and including also (a) the amount and rate of percolation into the soil under different soil surface conditions, (b) transpiration and evaporation loss from masses of soil 3 or 4 feet deep, and (c) influences of vegetation and organic matter on surface runoff and soil erosion.

Small watersheds of 5 to 15 acres in duplicate will be used for experiments on the effect of erosion control practices upon the rates and amounts of runoff and soil erosion for rainfall of different amounts and intensities. Erosion control practices that will be used will depend upon their adaptability to the particular region. Some of these practices will be pasture, forest, cover and green manure crops, crop rotations, various tillage methods, strip cropping, and terracing. Where suitable watersheds are available, experiments will be conducted to determine the effect of shape, slope, and arrangement of drainage channels upon runoff and erosion.

Measurements of runoff and erosion on these small watersheds will be divided into two stages as follows: (1) All of the watersheds will be treated in a similar manner from the standpoint of cover for the purpose of determining the effect of inherent differences in the watersheds, due to a number of influencing factors that cannot be readily evaluated. The duration of this stage will likely be about five years, depending upon the normality of climatic and crop conditions during this period. (2) At the beginning of the second stage the best erosion control practices, as determined from the results of experiments on the soil erosion experiment stations, will be established on a number of the small watersheds, and cropping or vegetative conditions on the other watersheds will continue as during the first period to serve as an integrator of climatic conditions during the whole period of experimentation. The duration of the second stage will likely be about fifteen years. The results of these experiments will give definite information on the effect of various erosion control practices upon water conservation, runoff and flood control.

In the case of watersheds ranging in size from 30 to 5,000 acres, information on rates and amounts of runoff and erosion from rains of different amounts, durations, and intensities will be collected from watersheds of different sizes to determine the effect of size of watershed on the rate and amount of runoff. Similar land use practices and erosion control measures will be maintained on these watersheds so as to eliminate as far as possible any differences in runoff due to these practices. Wherever possible, studies will be made of the effect of shape of the watershed upon maximum rates of runoff. Also, where similar watersheds are available, comparisons will be made of the rates and amounts of runoff from watersheds with a cover of timber and watersheds where recommended land use practices are employed.

Also measurements will be made to determine the time of concentration for watersheds of different cover, shape, and size for use in establishing the reliability of the rational method of computing runoff. The accuracy of several other recommended methods for computing runoff will also be investigated by comparison of the rates of runoff computed by these methods with actual measured rates of runoff. Investigations will also be made relating to the lag in the rate of runoff due to storage on the watershed and upon the effect of channel storage and flood waves upon runoff intensities.

It was originally planned to select two rather similar watersheds of about 5,000 acres each, conduct runoff and other investigations on both watersheds under present land use practices for the first stage of the experimental studies, then put into practice improved land use and erosion control methods on one of the watersheds and continue the other of the two large watersheds under the same practices that were used during the first stage. This would give an opportunity to secure comparable data on the effects of proper land use and erosion control practices upon water conservation, runoff and flood control for comparatively large areas, which would be highly desirable, since the laws governing stream flow from large areas are known to be

RELATIONSHIP OF GROUND-WATER TO STREAM FLOW

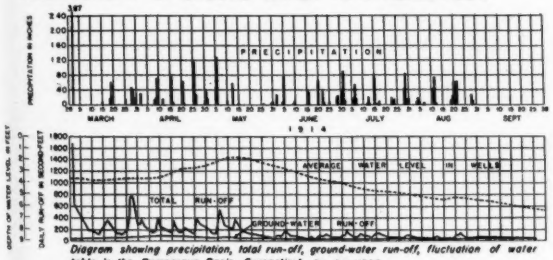
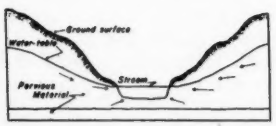


Diagram showing precipitation, total run-off, ground-water run-off, fluctuation of water table in the Pomperaug Basin, Connecticut Data from USGS



Section of typical watershed showing action of ground-water in stabilizing stream flow

considerably different from those for small areas. However, this plan was discussed with some practical soil conservationists, and they were of the opinion that the government would be subject to criticism if an attempt were made to prevent any improved land use and erosion control practices on an area as large as 5,000 acres in order to secure the desired comparative data. The plan for comparing two 5,000-acre watersheds has been abandoned and it has been decided to select a watershed area of about 400 or 500 acres outside of but adjacent to the large 5,000-acre watershed. This watershed area outside of the large watershed would be purchased by the federal government and present land use methods would be continued on this watershed throughout the life of the experimental studies. The results from this watershed would be compared with the results from a similar watershed within the large master watershed where land use and erosion control methods would be practiced during the second stage of the experimental studies.

Complete basic surveys will be made of all the watersheds to obtain information needed in connection with studies relating to the following factors: (1) soil erosion survey, including regular soil survey; (2) topography and physiography; (3) geology; (4) land use including general cover, crops, and agricultural practices; (5) groundwater, and (6) economic and social conditions. The land use survey will be repeated each year and the other surveys whenever advisable or necessary.

Field procedure and measurements will be as follows: (1) A sufficient number of automatic and standard rain gauges will be distributed over the watersheds to insure the collection of accurate data on rainfall distribution and intensities, as well as snowfall. (2) Meteorological instruments will be installed at strategic points over the watersheds, and one central station will be maintained where measurements of temperature, wind movement, evaporation, humidity, and atmospheric pressure will be made. (3) Both rates and amounts of runoff and eroded material will be measured. Parshall flumes for measuring runoff, and automatic silt samplers will be installed on the water courses where suitable locations can be found that will be comparatively free from backwater conditions. Where Parshall flumes are satisfactory, current-meter gauging stations will be established, and a sufficient number of gaugings will be made to define a rating curve for each station. Automatic water-stage recorders will be installed at Parshall flumes and gauging stations to obtain a continuous record of the water stages, and where wide variations in the slope of the water surface of the stream occurs, measurements of the slope of the water surface will also be made when current-meter gaugings and daily gauge readings are made.

The first watershed where experimental studies will be conducted is located near Coshocton, Ohio. A watershed of about 5,000 acres, typical of the North Appalachian region, was selected after office studies and field examinations had been made of about eighty-five possible sites. This experimental watershed is located on the watershed area of the Muskingum River and in the Muskingum Conservancy District. Officials of this district are much interested in these experimental studies since they will afford data of value to the District in the regulation and operation of fourteen large reservoirs being constructed for flood control purposes. Considerable progress has been made at Coshocton in preliminary work relating to the construction of necessary roads leading to proposed experimental installations, and the installation of rainfall, runoff and groundwater measuring equipment.

The second experimental watershed has been established in the Black Land region of Texas near Waco. It is located on the watershed of the Brazos River and in the Brazos River Reclamation and Conservation District. This district is likewise much interested in these studies, the results of which will be of value to them in the regulation and operation of thirteen large reservoirs to be constructed primarily for flood control purposes. The watershed selected is typical of the Black Land region. A survey and examination of seventy-three watersheds was made before a watershed was found that was representative of the Black Land region. Preliminary work has been started on this watershed relating to road construction, soil sampling, and the installation of groundwater wells. Plans are now being made for the installation of experimental measuring equipment.

Office studies and preliminary field investigations have been made for the establishment of an experimental watershed in the Great Plains region in Colorado, and some preliminary field investigations have been made in the Piedmont region for the selection of an experimental watershed in cooperation with the USDA Forest Service.

It may appear to some that the research work to be undertaken by the section of watershed and hydrologic studies duplicates to some extent the work that is now being carried on by the experiment stations of the section of soil and water conservation studies. One of the primary objects of the latter section is to determine by experimentation on small areas the most effective erosion control practices which are recommended for use on the operations projects, while the primary object of the watershed and hydrologic studies is to determine the effect of these recommended practices upon floods, runoff and water conservation from investigations on watershed areas ranging in size from a few acres to 5,000 acres, and to trace variations in this effect from the smallest watershed through a series of intermediate watersheds to the largest watershed of the experimental area.

Chemical Wealth in Sea Water

DURING the two and one-half years of the operation of the bromine plant of the Ethyl-Dow Chemical Company at Kure Beach, near Wilmington, North Carolina, one square mile of sea water, 172 feet deep, equivalent to 308,586,000,000 pounds, has been pumped in the process of producing bromine, of which the ocean harbors an inexhaustible supply.

Present in this quantity of sea water were materials with a total tonnage of 5,669,335, which if converted into cash at current quotations would bring $166,059,990. Bromine recovered commercially totalled over 10,000 tons. Potential by-products, not actually recovered from the sea water, and their values included:

Sodium chloride, 4,160,000 tons, $55,700,000; magnesium sulfate, 1,055,000 tons, $40,100,000; calcium chloride, 229,000 tons, $5,040,000; potassium chloride, 118,600 tons, $9,490,000; magnesium, 95,200 tons, $47,600,000; aluminum, 270 tons, $102,600; strontium carbonate, 314 tons, $188,500; iron, 284 tons, $17,050; copper, 18 tons, $3,420; iodine, 6.28 tons, $18,820; silver, 3.07 tons, $57,200; gold, 0.098 tons, $82,400.

Besides these main constituents, practically every element and compound is dissolved in the ocean water to a greater or lesser extent. In extracting bromine from sea water, now an established industrial operation, chemical science has accomplished the initial conquest of nature's greatest reservoir of minerals, though economic recovery of by-products is still a problem.

The Precooling of Fresh Fruit

By T. E. Hienton and K. I. Fawcett

PRECOOLING of carlots of fresh fruits and vegetables has increased very rapidly during recent years, and conservative estimates place the total number of such cars from California alone, in excess of 60,000 for the year 1935[1]. The practice of precooling, originally adopted for cross-country shipments, has become recognized as of sufficient economic value to warrant its use on many shipments destined for markets only a few hundred miles distant.

The economic importance of precooling arises from several factors including ability to reach more distant markets, enabling shippers to safely market products of higher quality which command premium prices, and reduction in losses from rots and excessive ripening during transit.

Precooling has been well defined as "a form of refrigeration employed for the rapid removal of the field heat from fruit before shipping, mainly in order to reduce the temperature to a point where ripening will be materially arrested and mold growth prevented." The spread of certain diseases of fruit in transit is definitely inhibited by temperatures of 45 degrees (Fahrenheit) or less. Of particular importance are the common black strawberry mold (*Rhizopus nigricans, Ehrb*) and the brown and Rhizopus rots of peaches.

Cars of strawberries, peaches, and cantaloupes from which the field heat had been partially removed, and similar check cars without precooling have been followed to market destination by members of the agricultural engineering and horticultural departments of the Purdue University Agricultural Experiment Station. Temperatures of the strawberries, at time of shipment in the precooled car, averaged 47.8 degrees in ten locations in the top and bottom tiers of crates in the center row. The average in the nonprecooled car was 58.9 degrees. These berries were shipped together from a southern Indiana point to St. Paul, Minnesota, a distance of about 600 miles, arriving in 24 hours. The nonprecooled berries were inspected at 8:00 a.m. the second morning by an official inspector and 2 to 3 per cent decay reported. The precooled car was forwarded about 250 miles farther and inspected at the same time as the other, but showed little decay and few soft berries. Following this test trip, buyers refused to purchase berries which were not precooled, except at a reduction of 15 cents per crate or $63 per car, although willing to pay a $15 charge for the precooling.

The temperature records of these cars, expressed in degrees Fahrenheit, are as follows:

	Precooled		Nonprecooled	
	Top	Bottom	Top	Bottom
June 10, 8:00 p.m.	46.8	48.8	61.2	56.6 (Time of shipment)
" 10, 11:00 p.m.	49.0	40.8	59.8	52.0 (Enroute)
" 11, 4:30 a.m.	48.4		54.6	45.2 (Enroute)
" 11, 9:25 p.m.	48.2	37.6	47.8	39.0 (8:25 p.m.)

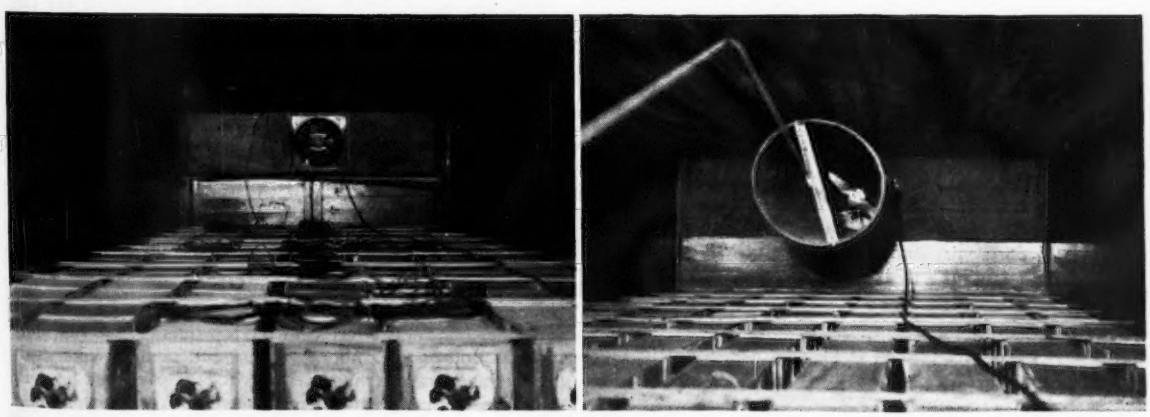
It is important to note that the top temperatures in the nonprecooled car were not as low after 24 hours as those in the precooled car were at time of shipment. A further important point is the rapidity with which temperatures in the bottom of the precooled car were lowered after shipment. The importance and value of precooling strawberries to low temperatures before shipment is well recognized in Louisiana, where fruit temperatures must be 45 degrees or less or the precooling company receives no payment for its services.

Records of temperatures in two cars of peaches, one precooled and the second a check, were reported in an article which appeared in AGRICULTURAL ENGINEERING for March 1935. The average temperatures in the cars were 64.0 and 72.6 degrees respectively, at time of shipment, but the peaches in the precooled car arrived in much the better condition of the two, although shipped only 300 miles. The peaches in the cars were not exactly alike, but all of the fruit in the precooled car arrived free from decay, while 4 to 16 per cent of a commercial pack in the second car showed evidence of brown rot. Inspection was made 37 hours after shipment.

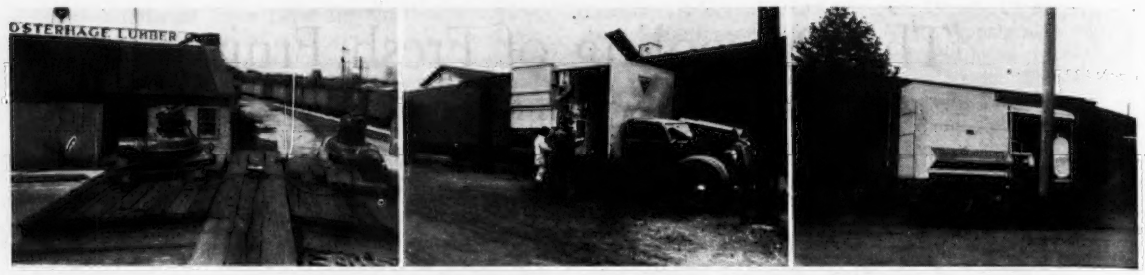
Presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Authors: Respectively, agricultural engineer (Mem. ASAE) and horticulturist, Purdue University Agricultural Experiment Station.

[1]Allen, F. W. and McKinnon, L. R. Precooling investigations with deciduous fruits. Calif. Agr. Exp. Sta. Bul. 590. 1935.



(LEFT) DISK FAN INSIDE OF CAR FOR CIRCULATING COOLED AIR THROUGH THE LOAD BEFORE SHIPMENT. ONE 18-INCH FAN IS USED AT EACH END OF CAR. (RIGHT) AIRPLANE-PROPELLER PRECOOLING FAN DRIVEN AT 3600 REVOLUTIONS PER MINUTE BY A ½-HP ELECTRIC MOTOR



(LEFT) MOTOR-DRIVEN BLOWERS USED IN BUNKERS OF REFRIGERATOR CARS TO PRECOOL FRESH FRUITS. THIS IS ONE OF THE FIRST TYPES OF EQUIPMENT USED FOR REVERSING NATURAL AIR CURRENTS INSIDE THE CAR. (CENTER) PRECOOLING A CAR OF STRAWBERRIES WITH A TRUCK-MOUNTED REFRIGERATION UNIT. (RIGHT) A TEST CAR OF PEACHES BEING PRECOOLED BY A TRUCK REFRIGERATION UNIT. THE REFRIGERATOR AND BLOWER ARE DRIVEN BY THE TRUCK MOTOR THROUGH A POWER TAKE-OFF

Observations of precooled and nonprecooled cars of cantaloupes, shipped a distance of 500 miles, revealed that the precooled ones on the top of the load ripened more slowly than did those not precooled. Similar tests and observations were made in 1935 by the U. S. Department of Agriculture and the University of California, cooperating, on cantaloupes shipped from California to eastern markets[2].

The practice of precooling is being used for many fruits and vegetables, as well as melons. Included in fruits which are being precooled commercially are apricots, cherries, citrus fruits, grapes, peaches, pears, and plums. Vegetables which are being precooled are chiefly asparagus and celery with some Irish potatoes in Florida and Louisiana in 1936. Of the melons, cantaloupes are the chief crop precooled.

Two methods of precooling are being employed, one in which the produce is cooled after being loaded into refrigerator cars, and the other in warehouse rooms. All of the precooling in Indiana is being done in refrigerator cars, as is the majority of precooling in other districts. Dr. W. T. Pentzer, physiologist of the USDA Bureau of Plant Industry, at Fresno, California, estimates that 40 per cent of the cherries, 55 per cent of the pears, and most of the citrus fruits precooled in California in 1935 were precooled in warehouse rooms. Small percentages of apricots, peaches, plums and celery were also precooled by this method.

Investigational work in Indiana, initiated in 1933, has been confined entirely to the method of precooling in cars, because of the large investment involved in the other method and its seasonal use. The first fans used were merely ventilating fans, commonly used in kitchens. Three, and later five, were mounted as a unit in each end of the car at the upper openings into the ice bunkers. These fans were of the propeller type, of 12-inch diameter, operating at 1200 revolutions per minute. Similar fans operating at 1800 rpm were also employed in the tests. Tests in 1935 included 18-inch, 1750-rpm fans of the same type as the smaller ones, one at each end; 18-inch, 1750-rpm disk fans, one at each end, driven by ¾-horsepower motors; blowers of the Galloway type, one in each hatch; and a truck unit with refrigeration machine and blower driven through a power take-off from the truck motor.

The fastest rate of cooling cantaloupes was obtained by using the two 18-inch disk fans. The truck unit was not used for precooling cantaloupes but was employed to precool peaches. A direct comparison of rate of cooling between these two types of equipment was obtained and the data entered in the following table:

COMPARISON OF TYPES OF PRECOOLING EQUIPMENT

Car number	Temp. start		Temp. drop		Salt, pounds	Time precooled, hr - min
	Top	Bottom	Top	Bottom		
	deg F		deg F			
	Two 18-inch fans					
48	77.4	74.4	13.0	8.8	400	4 — 2)
50	76.8	76.6	11.2	11.8	400	4 —
51	82.6	80.2	11.8	9.6	400	3 — 53
53	73.7	73.0	12.7	8.3	400	4 —
Average	77.6	76.0	12.2	9.6	400	4 — 5
	Truck unit					
49	84.2	79.2	14.0	14.2		4 —
52	82.0	78.6	13.2	11.6		4 —
Average	83.1	78.9	13.6	12.9		4 —

It will be noted that the average temperature drop effected with the truck unit during a 4-hour period was 13.6 degrees in the top tier and 12.9 degrees in the bottom tier. During an approximately equal length of time the fans effected a temperature drop of 12.2 and 9.6 degrees, respectively. The slight difference in drop in favor of the truck unit was undoubtedly due to the lower temperature of the air produced by it. Temperatures of air entering the car were 29 degrees after two hours operation and 20 degrees after four hours. The lowest air temperature reached, when the fans were used, was 35 degrees after four hours operation, starting with bunkers full of ice and 400 pounds of salt per car.

Other types of equipment which have been or are being used in the United States, for precooling produce in cars after loading, include a battery of fans placed in the center of the car, a blower and ducts used outside of the car, an airplane propeller fan of two blades driven at 3450 rpm, and a Sirocco fan and cold air or brine taken from a cold storage of precooling plant.

Certain factors affect the rate at which precooling is effected, including the produce and its initial temperature, air temperature, movement of air, type of container, and method of loading the car.

Tests have been made by the Indiana station on problems related to these factors. One which affects the air temperature is the amount of salt used on the ice. In 1935 thirteen cars of strawberries were precooled in tests in which salt was used in amounts of 100, 200, 300, and 400 pounds per car. An average temperature drop of 9.1 degrees per hour was affected in the top tiers of five cars during a period of 2.55 hours. Where 200 pounds were used, the average drop in five cars was 8.2 degrees per hour in 2.18 hours. In one car where 100 pounds of salt were used the drop was 5.5 degrees per hour for 2.5 hours. These results indicate that the amount of *(Continued on page 382)*

[2]Summary of cantaloupe precooling and shipping tests, 1935. U. S. Dept. of Agr. and Univ. of California cooperating. Feb. 13, 1936.

Effect of Particle Size of Dusts in Testing Internal-Combustion Engine Air Cleaners

By F. A. Brooks

SOIL OPERATIONS in agriculture almost inevitably raise a dust which damages machinery and irritates men. The dust problem must be considered permanent as there is no prospect of avoiding all soil manipulation. Apparatus that can be completely enclosed and does not use outside air can be sealed against ordinary dust, but internal-combustion engines and human beings have to use air, and if they are working in a cloud of dust some filtering means is essential for continued operation.

The economic value of air cleaners for tractor engines can be estimated from the saving in engine repair costs, which are so large under ordinary dust conditions that the cleaner cost is unimportant. The selection of air cleaners then becomes a question of comparative performance, and this in turn varies with the nature of the dust. There are many other important variables such as change of efficiency with change of air flow and servicing requirements, which are beyond the scope of this paper.

There has been a conflict in methods and results of testing air cleaners for the last 15 years of which the important disagreement has been in regard to the dust-catching efficiency when the cleaner is freshly serviced and operated under normal rated conditions. In general, our laboratory tests, reported by the late A. H. Hoffman, have shown lower efficiencies than found by the manufacturers. This discrepancy was properly ascribed to our use of finer test dust, but until now no investigation has been undertaken to measure the effect of particle size. Air-cleaner tests with an ultra-fine dust, with the regular California No. 3, and with a coarse dust give strikingly different efficiency results, and in addition permit a better understanding of air-cleaner characteristics.

The dry centrifugal cleaner is by nature most susceptible to the particle size. Tests on a high-grade cyclone-type tractor air cleaner indicates a progressive falling off of dust catching efficiency shown in Fig. 1, such as would be expected from centrifugal theory. All conditions such as rate of air flow, rate of dust feed, drying of the dust, etc., were maintained as constant as possible for the three runs. The cleaner was rapped continuously during the standard and fine dust tests to prevent clogging. The dotted line indicates the efficiency to be expected from large size industrial cyclone separators[1] operating at a restriction of about one-fourth that of the tractor air cleaner.

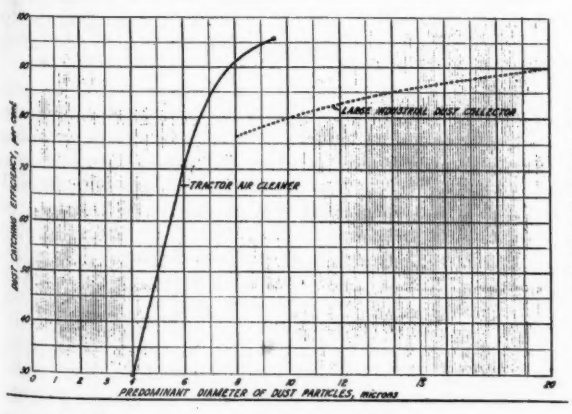
The usual tractor-type oil-bath cleaners with filter elements kept wet by oil spray should be less affected by particle size, yet it is obvious that sub-microscopic particles so small that they exhibit Brownian movement and might be considered as large gas molecules can float through the filter unless they happen to move into a boundary layer. Results of tests shown in Fig. 2 reveal a pronounced particle-size effect that amply explains the different efficiencies found by different investigators. To facilitate comparison with other types of air cleaners, the dashed curve at the top shows the test results for a felt filter which is only slightly affected by particle size, and the dotted curve shows again the test results for the cyclone type.

Study of Fig. 2 showing large variation of dust-catching efficiency with change of particle size makes it necessary to consider what is meant by the particle size of a dust which contains particles ranging from the sub-microscopic to, say, 50 microns in diameter (which is the soil-science lower limit of very fine sand, namely, that retained by a 300-mesh screen). A simple size distribution curve is unsatisfactory because of the thousands of particles at the lower limit of visibility which are counted or not, depending on the refinement of microscope technique. The specific surface, of prime importance to the cement industry, probably does not represent the characteristic of the dust that causes engine wear. Air-cleaner tests usually are made on the basis of weight of dust fed into the cleaner and the weight of dust

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Estes Park, Colorado, June 1936.

Author: Associate agricultural engineer, California Agricultural Experiment Station. Mem. ASAE.

[1] Van Tongeren, Herman, "A Modern Dust Collector," Mechanical Engineering, 57 (12) : 758, December 1935.


LARGE INDUSTRIAL DUST COLLECTOR
TRACTOR AIR CLEANER
DUST CATCHING EFFICIENCY, PER CENT
PREDOMINANT DIAMETER OF DUST PARTICLES, microns

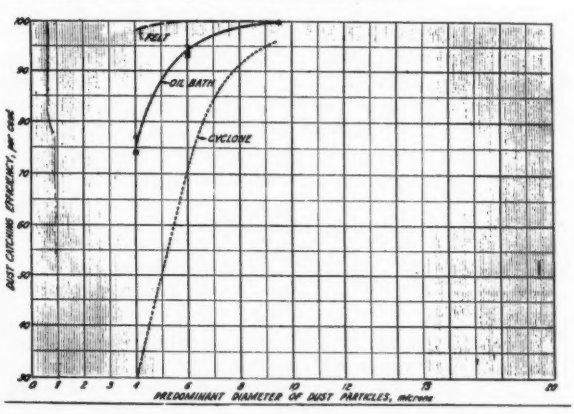
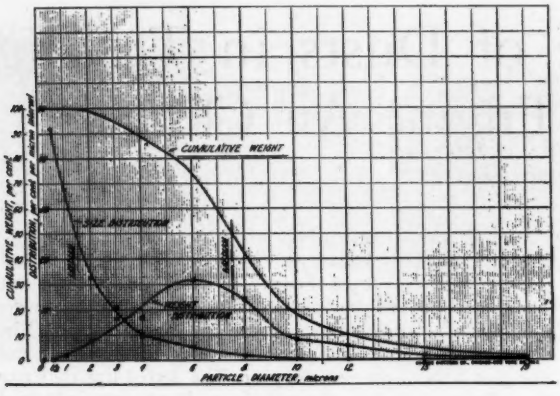


FIG. 1 (LEFT) EFFICIENCY OF CYCLONE-TYPE AIR CLEANERS. FIG. 2 (RIGHT) EFFICIENCIES OF OIL-BATH AIR CLEANERS, FELT FILTERS, AND CYCLONE AIR CLEANERS



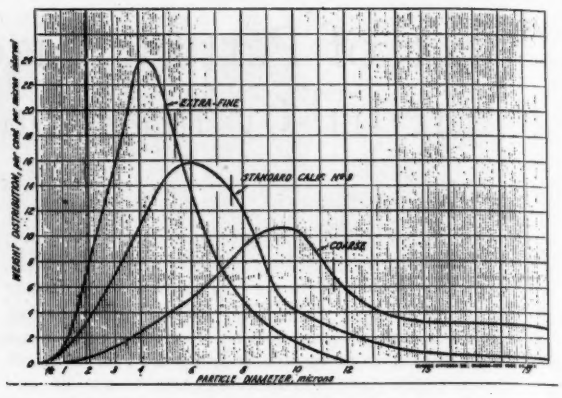


FIG. 3 (LEFT) CALIFORNIA NO. 3 STANDARD DUST, 1933-36. FIG. 4 (RIGHT) WEIGHT DISTRIBUTION OF EXTRA-FINE, CALIFORNIA NO. 3, AND COARSE TEST DUSTS, 1936

passing through. This basis corresponds to the cube of particle size, but yet may not be the best wear-producing criterion.

It is generally assumed that in operating a tractor engine under severe dust conditions a good oil-bath air filter will reduce the rate of wear to maybe 1/200 or 1/400 that expected with no protection and no change of crankcase oil. In other words, the dust that is not caught by the regular type of air cleaner causes about ½ to ¼ of one per cent as much wear as would occur with no protection. Whether this corresponds to the efficiency by weight to be expected from the air cleaner in the dust encountered cannot be stated at present. There are at least two qualifying factors: (1) the amount of dust retained by the engine, and (2) the treatment of the crankcase lubricating oil.

Tests to determine what portion of dust remains in a small four-cylinder, four-cycle engine and what passes on out through the exhaust port proved unreliable because the dust caused the engine to misfire and too much oil vapor reached the filter cloth. Tests on this engine when driven by a motor showed 92 per cent retention of both the California No. 3 dust and the coarse dust. A test with medium-fine dust showed 88 per cent retention. Tests with extra-fine dust could not be run for lack of such dust, but it can be assumed that the engine would retain less than the 75 per cent caught by the oil-bath air cleaners.

The effect of crankcase oil treatment in modifying the effect of dust is seen in tests[2] during road construction where new oil every 100 hours kept the rate of wear for the unprotected engine below that expected for normal operation with ordinary air cleaners. Furthermore, in the "fine-dust" districts tractor operators have found recently that even with properly serviced oil-bath cleaners and oil filters, it is most economical also to use cheap lubricating oil and drain the engine every 35 or 40 hours.

Since it is not possible to evaluate the effect of crankcase oil change in terms of wear ascribable to dust particle size, we can only assume that a given weight of fine dust will cause a less damage than the same weight of coarse dust, but that the coarse dust is less likely to remain in circulation in the lubricating oil. This negative conclusion leads us to continue with the weight procedure for air-cleaner testing.

Almost all methods of estimating particle size are founded on direct microscopic analysis. One can make only about 2,000 estimates of particle size in a period of 3 or 4 hours, and if the fields examined happened to include one lone 15-micron particle on one sample slide and did not include a similar particle on another sample slide of the same dust, the result in terms of weight would be unreliable, because a single 15-micron particle weighs more than 3,000 one-micron particles. It is therefore essential to scan large areas for the large particles and estimate as well as time permits the size distribution of the small particles.

Special equipment was obtained to permit better microscopic study of the dusts, dry. Dark-field illumination was provided above surface by two lamps, opposite one another. Using a 40X, 4.3-millimeter objective, 0.95 N.A., and 15X ocular, the sizes of the small particles were estimated as follows:

½ micron = strong points of light (stars)
1 " = apparent body (planet) or double image
2 " = definite shape
3 " = ¼ of ocular micrometer grid (12 squares)
4 " = ⅓ of ocular micrometer grid (12 squares)

The diffraction is so pronounced and the focal plane so shallow that in all cases it is necessary to use the fine adjustment to get a clear image of different size particles or of the same size particles in different parts of the field. Particles larger than 4 microns are difficult to estimate because no one plane gives a clear image. A 22X, 8.3 millimeter objective, 0.65 N.A., is therefore used for counting and estimating the size of particles from 4 to 19 microns by comparing with a 24-micron grid. The low power 9X, 18 millimeter objective, 0.20 N.A. is used for gauging the 19-micron particles and larger against the ocular micrometer squares of 48 microns.

The examining procedure is to cover a field in strips 0.4 by 25 millimeters with the 9X objective using a mechanical stage and reading at even millimeters, recording the 19 and 23-micron particles and noting the dimensions of long particles and of larger ones. Then with the 22X objective, the same fields, but of one-fourth the area, are examined for particles of 4, 6, 8, 10, 12, 15, and 19 microns average diameter. Again at the same mechanical stage settings the smallest particles are examined with the 40X objective, the field now being one-sixteenth that of the 9X objective. The counts with the 22X and 40X objectives are multiplied by 4 and by 16, respectively, and the overlapping readings of 19-micron and 4-micron groups each averaged.

To obtain a fair dust sample on a microscope slide the test dusts were dispersed by the regular rotating air jet used in cleaner tests and sucked through an inverted 4-quart

[2]Stalnaker, R. H., "Results of Tests of Air Cleaners on Trucks in Service," California Highways, 2 (4) : 3, April, 1925.

butter churn bottle. A carefully cleaned slide enclosed in a bayonet case 4 inches below the bottle bottom was then uncovered and the dust allowed to settle at least two hours. Blank runs were made to determine the correction for laboratory dust. Fig. 3 shows the results obtained from the California No. 3 dust which was prepared under Mr. Hoffman's direction.

The size-frequency curve does not clearly indicate the dust characteristics of interest from an engine-wear standpoint. Multiplying the numbers of particles of each size by the cube of the average diameter yields a weight distribution curve which is more significant. It is seen that 6 microns is the predominant particle size on a weight basis. The median at 7.5 microns shows that the weight of 752 particles 8 microns diameter and larger is equal to the combined weight of 14,226 smaller particles. The total weight curve is calculated starting with the largest particles. This curve indicates that, if an air cleaner caught all dust particles larger than 3 microns, it would test 95 per cent efficient although it retained only about one-quarter the number of particles of the California No. 3 dust.

Fig. 4 shows the weight distribution curves of the three dusts used in tests shown in Fig. 2. The coarse dust had previously been caught by the cyclone cleaner. The extra-fine dust was gathered from the end filter cloth of our airflow sedimentation chamber[3]. These dusts are not field dusts and are to be considered only as specialized test dusts, each representing a portion of any dust encountered in the field.

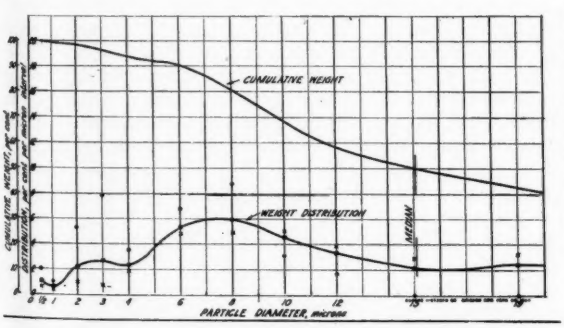
Field dusts are always different, of course, for each soil, each implement, and each weather condition. The most serious dust conditions arise at the end of a long dry summer and are most severe in cultivating dry fallow land. Comprehensive studies have not been made of agricultural field dusts, although there is a considerable literature on mining and industrial dust constituting explosion or health hazards. The dust-sampling instruments[4] commonly used for these purposes are limited in range of particle size and tend to reduce flocculated particles. The thermal precipitator[5] developed by Mr. Whytlaw-Gray in England appears more promising, but as this type was not available a simple sedimentation cell was used to get samples of airborn dust. This cell consisted of a 4-inch soil-sample can with a carefully cleaned microscope slide in the bottom. The can was opened momentarily in a thin dust cloud and then again sealed. A minimum settling time of 3 hours was allowed before removing the slide for microscope examination.

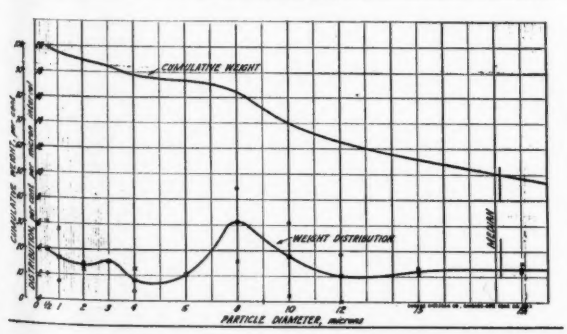
Although it is early in the season and the dust conditions are not severe, Mr. Sjogren suggested the Fresno-Parlier district as having fine dust. Mr. Fairbank kindly made an excursion, but found only one implement working between Fowler and Parlier—a 4-horse team pulling a furrowing machine in a vineyard. The driver said "it is very dusty when dry," so this sample must be coarser than would be found in the late summer. Other conditions were favorable for getting a good sample. The afternoon was hot and dry and there was little wind. Mr. Fairbank exposed two sedimentation cans 75 feet from the implement. The microscope counts of about 25,000 particles covered an area on each slide of 4 by 25 millimeters. The weight distribution curve and the cumulative weight curve shown in Fig. 5 are of the combined counts. In spite of the large counts, the results of the two slides differ greatly as can be seen from the plotted observations in circles and crosses, respectively. This difference indicates either a wide divergence in dust

[3]Brooks, F. A., "A New Method of Obtaining Dust for Testing Tractor Air Cleaners," Agricultural Engineering, 16 (8) : 325, August, 1935.

[4]Bloomfield, J. J. and J. M. Dallavale, "The Determination and Control of Industrial Dust," U. S. Treasury Department, Public Health Bulletin No. 217, p. 10-37, April 1935.

[5]Green, H. L. and H. H. Watson, "Physical Methods for the Estimation of Dust Hazard in Industry," Privy Council, Medical Research Council, special report series No. 199, His Majesty's Stationery Office, London; p. 23-37, 1935. Methods of precise determination of the size-frequency of dust particles using ultra-microscope technique and specially made sedimentation cells have been developed by Mr. Green, in "Some Accurate Methods of Determining the Number and Size-frequency of Particles in Dust," Journal of Industrial Hygiene *16* (1) : 29-39; Jan. 1934. Mr. Green's determinations of particles as small as 0.2 microns demonstrates the expected dropping off of the number of particles below ½ micron in a sandstone dust cloud, and indicate that with probable distribution these sub-microscopic particles are unimportant when interpreted on a weight basis.





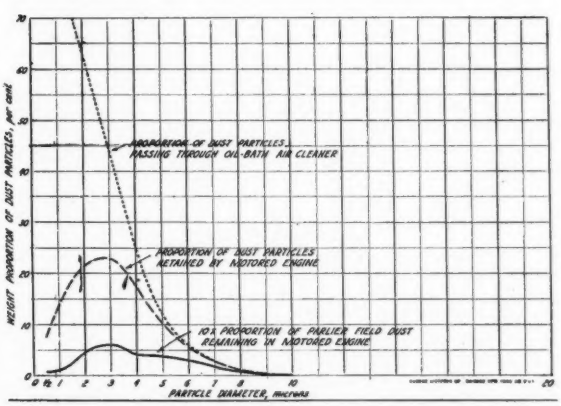

PROPORTION OF DUST PARTICLES PASSING THROUGH OIL-BATH AIR CLEANER
PROPORTION OF DUST PARTICLES RETAINED BY MOTORED ENGINE
10 X PROPORTION OF PARLIER FIELD DUST REMAINING IN MOTORED ENGINE
WEIGHT PROPORTION OF DUST PARTICLES, PER CENT
PARTICLE DIAMETER, microns

FIG. 5 (UPPER LEFT) PARLIER WHITE ASH DUST. FIG. 6 (LOWER LEFT) TYLER ISLAND PEAT SOIL DUST. FIG. 7 (RIGHT) PROPORTION OF FIELD DUST RETAINED BY A MOTOR-DRIVEN ENGINE

raised by the implement when going and coming or else unsatisfactory sampling and counting technique.

Fig. 6 shows the air dust samples taken in May in the fine peat soil district in Sacramento-San Joaquin Delta. This study explains the anomalous report of sealed magnetos failing from fine dust infiltration and simultaneously the successful application of cyclone air cleaners which were known to be useless for fine dust. The weight distribution curve shows a large quantity of ultra-fine dust, a relative scarcity of particles 4 to 6 microns in diameter and the bulk the weight above 8 microns which is readily caught by cyclonic collectors.

CONCLUSION

To gauge the field performance of air cleaners it is most useful to estimate the amount of field dust remaining in an engine. Experimental data is too meager to make dependable estimates, but some use can be made of the information now at hand. In Fig. 7 the dotted line indicates the approximate proportion of dust particles passing through the common type oil-bath air cleaner. Some of these particles float on through the engine also, but using the figures for retention observed with a motored engine the approximate proportion, by weight, of particles remaining in an engine can be estimated as shown by the dashed line. Applying this curve to the field dust distribution curve of Fig. 5, there is obtained the proportion of field dust remaining in an engine (full line curve, Fig. 7) which in this example totals 2½ per cent.

Applying the engine retention proportion curve (dashed line, Fig. 7) to the peat soil dust shown in Fig. 6, the estimate for the amount of field dust remaining in the engine is again about 2½ per cent. Of two field dusts obtained in the Imperial Valley, one by Mr. Fairbank near Calipatria June 8 from a 40-horsepower wheel tractor with disk plow plowing alfalfa sod indicates about 1½ per cent retained in the engine; and the other by N. R. Bangert[6] near Holtville, 10 feet from a passing 45-horsepower track-type tractor with spike-tooth drag, indicates approximately ¼ of one per cent remains in the engine.

Considering the recognized fineness of the first two field dusts, these four estimates of 2½, 2½, 1½, and ¼ per cent of the weight of field dust passing through an oil-bath air cleaner and remaining in the engine are in fair agreement with the ½ to ¼ per cent rate of wear usually assumed with this type of air-cleaner protection. Therefore, it seems desirable to continue this research on the effect of particle size of dust and obtain more reliable data on engine retention and a large number of samples of the dust actually drawn into the cleaner.

[6]Assistant maintenance engineer, California State Division of Highways.

The Precooling of Fresh Fruit

(Continued from page 378)

salt to be used will depend upon the initial temperature of the fruit and the time available for precooling; the shorter the time and the warmer the fruit, the more salt should be used. The top limit for strawberries seems to be about 800 pounds per car, from experiences reported in southern states.

The container in which the produce is shipped may affect directly the rate of precooling. Crates are usually well suited for precooling since the air may pass through them around the produce. Certain baskets, such as the tub type of basket, are practically air-tight, especially when paper liners are placed inside them and pads and lids over the tops, as is usually done with peaches. The resulting effect is to practically insulate the peaches from the air so that heat is lost only by conduction through the basket itself.

Tests were conducted in 1935 using two ventilated types of baskets in comparison with the standard tub basket most commonly used in the Indiana and Illinois peach district. Results of these tests are listed in the following table:

Car	Baskets	Temp. start Top	Temp. start Bottom	Temp. drop Top	Temp. drop Bottom	Time precooled, hr - min
49	Ordinary	84.2	79.2	14.0	14.2	4 — 00
	*Vent. No. 1	75.7	71.8	10.7	10.2	4 — 00
51	Ordinary	82.6	80.2	11.8	9.6	3 — 53
	†Vent. No. 1	76.4	72.8	17.6	6.6	3 — 53
52	Ordinary	82.0	78.6	13.2	11.6	4 — 00
	**Vent. No. 1	80.6	75.8	20.8	14.6	4 — 00
53	Ordinary	73.7	73.0	12.7	8.3	4 — 00
	††Vent. No. 2	75.5	71.2	16.3	11.0	4 — 00

*Six ½-inch holes bored in bottoms of ventilated baskets.

†Six 11/16-inch holes bored in bottoms of ventilated baskets and holes cut in pads to match those in lids. Regular lids used on bottom row, standard lids on top row.

**Six 1-inch holes cut in bottoms, lids and pads of ventilated baskets.

††Six 11/16-inch holes bored in bottoms of ventilated baskets and holes cut in pads to match those in lids.

IMPORTANCE OF CONTAINER VENTILATION TO SUCCESS AND ECONOMY OF PRECOOLING

It is interesting to note in car No. 49 that the ventilated baskets did not cool as much as the ordinary baskets despite the fact that six ½-inch holes had been bored in their bottoms. This is probably due to the fact that the movement of air is downward in the car and could not get into the basket. In car No. 50, the ventilated baskets (No. 1) in the bottom tier were equipped with the usual lids and holes punched in the pads to correspond with those in the wooden cover. Lids of standard baskets were used on the ventilated baskets in the top row and holes punched to correspond. The rate of cooling in those of the bottom row was less than for the ordinary baskets in that row, but that of those in the top row exceeded by about 50 per cent the ordinary baskets. (The lid of the ordinary basket is practically solid, with only four small openings.)

In tests with the No. 1 and ordinary baskets in car No. 52, the temperature drop in the ventilated baskets was decidedly greater than in the others. In this case six 1-inch holes were bored in the bottoms as well as lids and pads of the baskets to permit the movement of air through the peaches. The No. 2 baskets were compared with ordinary baskets in car No. 53 and the rate of cooling was also greater in this test for the ventilated baskets. However, as with the No. 1 baskets, holes were bored in the bottoms and holes punched in the pads to correspond with the openings in the lids.

It is readily apparent from these results that, if peaches are to be precooled in a reasonable length of time, the baskets, pads and paper liners must be constructed so as to allow a greater passage of air than is now possible. If this provision is not made and precooling is adopted, there will likely be a change in container from baskets to crates.

Control of High Soil Temperature

By G. E. P. Smith

AGRICULTURAL engineers have been called upon to solve the problems of soil heating under certain conditions, notably for nursery beds. In the Southwest the problems are quite different. There the need is for a moderate degree of soil cooling. This problem has been investigated quite thoroughly for citrus orchards and should be investigated for pecan and deciduous fruit orchards, berries, and even for cotton. Soil temperature control is needed, and is feasible, in southern Arizona, in Imperial and San Joaquin valleys in California, and perhaps farther east, for various crops near the southern limitation of their respective areas of production.

For young grapefruit orchards in Arizona it has been shown (1) that the soil temperatures between June 15 and September 15 exceed the point at which normal development may be expected; (2) that it is feasible to control the temperature by several methods, and (3) that the best method is by means of a thick, dry mulch of some material which will not heat when irrigated. The next best methods are by frequent, but light, irrigations and by the use of a cowpea cover crop.

The soil temperature studies were incidental to citrus irrigation studies, which were initiated in 1927 at the experiment farm of the University of Arizona on the Yuma Mesa, a benchland of sandy soil about 80 feet above the Colorado River bottomland. Eighteen plots of 52 trees each were used by the horticulture department for study of water-plant relationships and by the irrigation department for study of water-soil relationships. Later, in 1932 and 1933, the irrigation department added five plots of 39 trees each for direct comparison of five different methods of temperature control.

The mesa soil, which has a water-holding capacity of only 5 or 6 per cent, presents some unique problems, but with irrigation practice modified to fit the soil conditions, citrus and various other crops can be grown successfully. The mesa has the advantage of being practically frost free.

Soil temperature is controlled primarily by air temperature. A seasonal lag might be expected, but it is masked by two other factors, insolation and evaporation of water on or in the soil surface. Insolation raises the temperature and is of great importance in spring and early summer. Evaporation has the opposite effect, and its influence is felt following irrigations and rains.

The penetration of heat into the soil or its escape is much retarded, since the heat advances mainly by conduction, with some assistance of radiation across pore spaces. The inflow and outflow of air also is a minor factor.

It is found by means of thermograph records on Yuma Mesa that the lag in soil temperature behind the air temperature, for various depths, is as follows:

Depth in feet	Lag in hours
1	6 to 7
1.5	9 to 11
2	12 to 14
3	22 to 24

The soil temperature, even at a three-foot depth, shows a diurnal curve, but the maximum temperature at that depth, which occurs in the afternoon, is due to the air temperature maximum of the previous day. The daily range, which varies with the weather, is about as follows:

Depth in feet	Daily range in degrees (Fahrenheit)
1	3 to 6
1.5	2.5 to 4
2	1.5 to 3
3	0.3 to 1

The annual range on the Yuma Mesa is, from 50 to 60 degrees in December and January, to an extreme of about 100 degrees in the three summer months. The temperature at one-foot depth may change as much as 18 degrees in a single month in spring or fall. There is a surprising variation also between different years.

The effect of irrigation on the soil temperature of the second foot of soil, the center of the root zone, was studied in 1928 on a plot which received frequent irrigations. The results are shown in Fig. 1. The temperatures plotted are the night maxima for the night before, the second night after, and the fifth night after irrigation. The maximum effect is shown usually on the second night, and the fifth night temperature shows partial recovery from the effect of the irrigation. Fig. 1 shows that by reason of the irrigations the soil temperature was kept well below the danger point.

Although the water was sometimes cooler than the soil, sometimes warmer, and though the air temperature changes were sometimes upward, sometimes downward, yet without a single exception, the soil temperature was lowered as a result of the irrigation. The average lowering was 4 degrees. In every case but two, there was a rise in temperature during the following three days, the exceptions occurring in periods of cool weather, in October and November.

In Fig. 2 are presented the records for 12 months, from thermographs in the citrus irrigation tract at Yuma and in an orchard near Litchfield, about 25 miles west of Phoenix, the depths of observation being one and three feet. The effects of irrigations and of rains are pronounced at one foot depth and are measurable at three feet. The points observed were in the row midway between trees; soil temperatures directly beneath mature trees have been observed to be 3 to 7 degrees cooler; in this respect a mature tree

Presented before the Irrigation and Drainage Research Association, at Estes Park, Colo., June 1936.

Author: Professor of irrigation engineering, University of Arizona. Mem. ASAE.

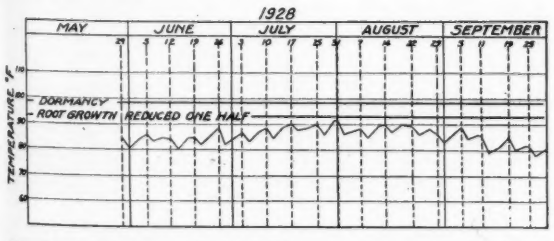


FIG. 1 SOIL TEMPERATURE RECORDS FOR THE SECOND FOOT OF SOIL, DURING SUMMER MONTHS, TAKEN IN AN ORCHARD OF YOUNG GRAPEFRUIT TREES ON HIGH BENCHLAND SOUTH OF YUMA. DOTTED VERTICAL LINES SHOW DATES OF IRRIGATION, WHICH ARE FOLLOWED BY LOWERING SOIL TEMPERATURES

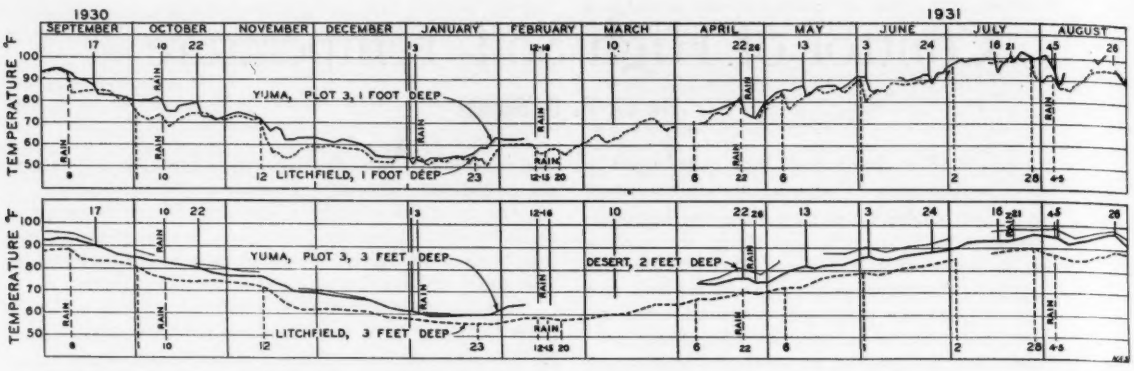


FIG. 2 TWELVE-MONTH RECORDS OF SOIL TEMPERATURE IN CITRUS ORCHARDS ON THE YUMA MESA AND AT LITCHFIELD IN THE SALT RIVER VALLEY. THE POINTS PLOTTED ARE THE DAILY MAXIMA TAKEN FROM CONTINUOUS RECORDERS. VERTICAL LINES SHOW THE DATES OF IRRIGATION AND OF RAIN. THE LIGHT, SOLID LINE GIVES A PARTIAL TEMPERATURE RECORD OF DRY DESERT SOIL NEAR YUMA ORCHARD

has protection which a young tree lacks. The desert soil temperature for short periods is plotted on Fig. 2; it is higher than that of irrigated soil.

Comparing the temperatures at one and three feet, it is seen that there is greater warmth at three feet depth in fall and winter, and higher temperature at one foot in spring and early summer, when the flow of heat is into the soil.

From the many records kept during the past eight years, it is found that the effect of the lowering due to an irrigation is finally lost in two weeks or less. With irrigation frequency of a week or 10 days an advantage due to the lower temperature is continuous.

The reduction on the second night after irrigation for different depths is as follows:

Depth in feet	Reduction in degrees
1	4 to 10
1.5	2.5 to 6.5
2	1 to 4
3	0.5 to 2

The cooling of the soil is due primarily to the evaporation of water on or near the soil surface. The temperature of the canal water is a minor factor.

The records of the 18 plots planted in 1927 showed that the more frequent the irrigations, the more rapid the growth. The trees on the plots irrigated weekly developed full, dark, luxuriant foliage, grew rapidly, and began early to bear fruit. The correlation between irrigation frequency and growth was perfect. Since, in the case of less frequently irrigated trees, there was no lack of available soil moisture, the conclusion was reached that the dormancy in summer and the lack of growth of those trees were due to high soil temperatures.

Previous to 1927, much difficulty had been had with young orchards on Yuma Mesa. In two or three years no more growth was made than should be made in one year. The belief had somehow become quite general that it was desirable and essential that the soil should become dry almost to the wilting point before irrigation. The marvelous performance of the trees irrigated weekly showed this belief to be wholly fallacious.

For comparison with the method of frequent irrigations, preliminary trials of other methods of soil cooling were tried. A gray tar paper appeared to have no effect, and a loose earth mulch had very little. A mulch of alfalfa straw lowered the temperature 5 degrees until the next irrigation, after which the advantage was only 2 degrees. In another test the straw heated after irrigation and the soil beneath it was hotter than adjacent ground. In a nearby orchard an alfalfa cover crop occupied about two-thirds of the ground surface. Two thermometers were set in May at one foot depth, one in the alfalfa and one eight feet away in bare soil. The advantage gained by the alfalfa was 6.5 degrees both before and after irrigation, and the lowering caused by the irrigation was 5 degrees. A similar test in April in a cover crop of Hubam clover, at two feet depth, showed a reduction in the clover of 6.7 degrees three days after irrigation and 8.1 degrees a week later. Since the reduction is needed only from about the middle of June to the middle of September, it was thought that a summer cover crop such as cowpeas could best accomplish the desired control.

In order to make comparable, positive tests of various methods of temperature control, four plots of 39 nursery trees each, were set out in the spring of 1932. One plot was irrigated weekly. On this plot three trees were provided with canvas shelters eight feet square, set about 10 inches above the ground. Plot 2 was planted with a cover

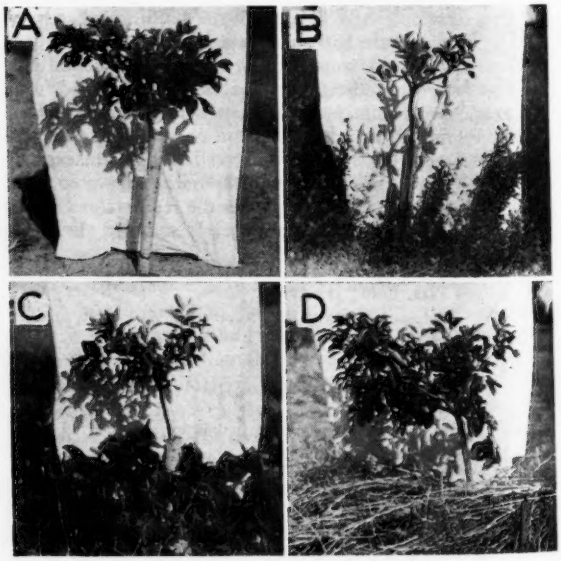


FIG. 3 TYPICAL YOUNG GRAPEFRUIT TREES FROM SEPARATE PLOTS SPECIALLY TREATED TO PREVENT EXCESSIVELY HIGH SOIL TEMPERATURES. A, PLOT FREQUENTLY IRRIGATED. B, PLOT WITH ALFALFA COVER CROP. C, PLOT WITH COWPEA COVER CROP. D, PLOT WITH A THICK MAT OF DRY, COARSE CLOVER STRAW AROUND EACH TREE. TREES FROM THE LATTER PLOT SHOWED MOST VIGOROUS GROWTH

FIG. 4 (LEFT) VIEW LENGTHWISE ALONG TWO ROWS OF PLOT 3, SHOWING THE EXCELLENT, UNIFORM GROWTH OF THE TREES PROTECTED THE FIRST FOUR YEARS BY MEANS OF DRY STRAW MULCHES. FIG. 5 (RIGHT) VIEW CROSSWISE OF THE PLOTS. THE TREES IN THE FOREGROUND ARE THOSE OF PLOT 1, IRRIGATED WEEKLY THROUGH THE SUMMER. THOSE IN THE BACKGROUND ARE THE TREES OF PLOT 3. DIRECTLY BEHIND THE MEN ARE SOME OF THE SMALL TREES OF PLOT 2, WHICH HAD A COVER CROP OF ALFALFA THE FIRST THREE YEARS

crop of alfalfa. On plot 3 a mat of dry Hubam clover was placed around each tree. On plot 4 a cover crop of Brabham cowpeas was sown. Somewhat later it was learned that citrus growers in Imperial Valley were using sesbania (wild hemp) as a cover crop and so another plot was started in 1933 with sesbania planted along each tree row. The various conditions during the first year are shown in Fig. 3.

In these tests the growth on plot 3, with the dry mulches, has far exceeded that with any other treatment. A view showing the uniformity of the fine trees of this plot is presented in Fig. 4. They are shown in the background in Fig. 5, with the frequently irrigated trees in front and the small alfalfa-plot trees barely showing in between.

Comparisons of tree growth have been made by measuring two or three times each year the circumference of the tree trunks four inches above the bud union.

The comparisons are best exhibited by the graphs in Fig. 6. It is to be noted that the alfalfa was turned under in the fall of 1934, and that plot has been bare since then, with irrigations every two weeks through the summer. The shelter tents were used three years. Beginning in 1935, plot 1, the bare plot, was changed from weekly to 2-week intervals. In 1936 all the plots are on the same treatment. No chemical fertilizers have been used except, in 1934, on the alfalfa plot. It was feared that fertilization would confuse the results of the tests.

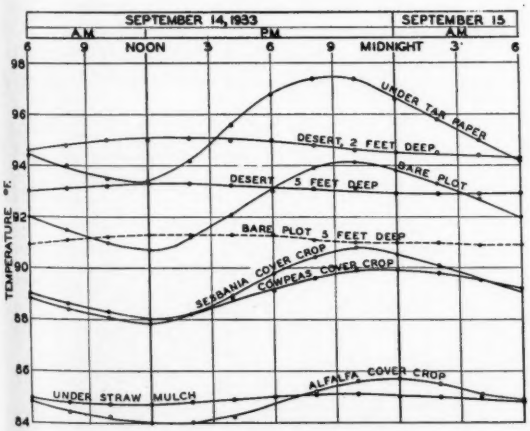


FIG. 6 GROWTH OF TREES UNDER VARIOUS METHODS OF SOIL TEMPERATURE CONTROL, AS DETERMINED BY MEASUREMENT OF THE TRUNK CIRCUMFERENCES A FEW INCHES ABOVE THE GROUND. TREES OF PLOT 3, WITH DRY MULCHES, HAVE MADE THE GREATEST GROWTH. PLOT 1, THE FREQUENTLY IRRIGATED BARE PLOT, RANKS SECOND. (THREE TREES OF PLOT 1 HAD ADDITIONAL PROTECTION OF CANVAS SHELTERS.) THE COWPEAS COVER CROP WAS NOT EFFECTIVE THE FIRST YEAR BECAUSE OF LATE START AND POOR STAND. PLOT 2 IS SHOWING RECOVERY SINCE REMOVAL OF THE ALFALFA

Fig. 7 shows the soil temperature readings over a 24-hour period on various plots, the soil under the roofing paper being the hottest and that under the dry straw mulch being the most thoroughly insulated. The diurnal curves show the minimum temperature at one foot depth to be at noon and the maximum at 10:00 p.m. The bare plot temperature was relatively high because eight days had elapsed since the last irrigation.

The failure of the trees on the alfalfa plot was disappointing. It is considered to be due to the crop competition for water and plant food, particularly in the early spring when bacterial activity is at a standstill. Cowpeas, if planted in late May, make no demand for plant food until late June, and they should be removed in mid-September. This was not done in 1935, and soil moisture records indicate that the trees were under severe water stress in October.

Field work connected with irrigation investigations demands the constant, personal attention of a trained research assistant. At the Yuma citrus experiment station there was such a man answerable to the irrigation department until the end of 1934. As long as he assisted in the irrigations, the frequency program, the depths of irrigation and the uniformity of distribution of water in the plots, were executed fairly satisfactorily. Since 1934 the quantities of water applied have been too heavy, and the distribution has not been uniform. Therefore, it is considered that the project was practically completed in 1934, though measurements on the tree trunks will be made through 1936.

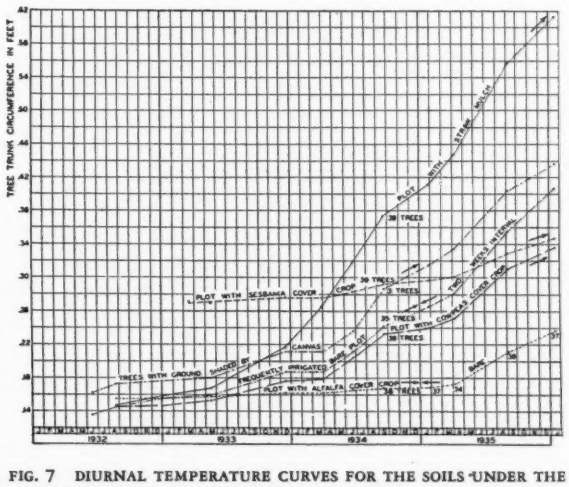


FIG. 7 DIURNAL TEMPERATURE CURVES FOR THE SOILS UNDER THE VARIOUS METHODS OF TEMPERATURE CONTROL. THE PLOTS HAD BEEN IRRIGATED SEPTEMBER 6, EIGHT DAYS PRIOR TO THE TEST, WHICH ACCOUNTS FOR THE RELATIVELY HIGH TEMPERATURE OF THE SOIL OF THE BARE PLOT

Application of Rainfall Intensity-Frequency Data

By D. L. Yarnell

IN DISCUSSING rainfall intensity data, it seems desirable that the following factors which have not been completely covered in USDA Miscellaneous Publication No. 204, entitled "Rainfall Intensity-Frequency Data," might be emphasized: (1) the runoff coefficient in the rational formula, (2) the time of concentration of a given watershed, and (3) the construction of flood-frequency curves from the rainfall data. For the benefit of those who have not seen this bulletin, its contents will be described briefly. On outline maps of the United States, isohyetals, or lines of equal precipitation, were drawn for durations of 5, 10, 15, 30, 60, and 120 minutes for frequencies of 2, 5, 10, 25, 50, and 100 years. Other maps were prepared showing isohyetals for durations of 4, 8, 16, and 24 hours for frequencies of 5, 10, 25, 50, and 100 years.

Prominent engineers qualified to speak on this subject were consulted during the preparation of these diagrams, and it is believed that an additional record of rainfall of 10 to 20 or more years will change the position of the isohyetals on these charts very little if at all. The charts should be consistent, one with another, that is, for a given duration; the intensity should remain either constant or increase with frequency. For a 2-hour duration the intensity for a 100-year frequency at any point on the chart must at least be the same as that for a 50-year frequency; it can be more but never less. The consistency of these diagrams has been checked at over 200 different points.

An engineer working in one locality probably will find it convenient to prepare from these diagrams an intensity chart of his own on which he can determine more easily the intensities for durations and frequencies other than those shown on these charts. Such a diagram, Fig. 1, has been prepared for Bethany, Missouri. For this station, intensity values were interpolated from the charts in the bulletin referred to above and plotted on logarithmic paper with duration as abscissa and intensity as ordinate. Intensities for durations and frequencies other than shown in the USDA charts may easily be read on such a diagram. In preparing such charts smooth curves should be drawn through the majority of the points for any given frequency. The engineer may prefer the other type of diagram, Fig. 2, with frequency as abscissa and rainfall in inches per hour as ordinate. Either diagram can be prepared from the USDA charts.

The USDA bulletin gives intensities which after conversion into inches per hour can be used directly in the rational formula for computing runoff and hence are of value to engineers. The rational formula is

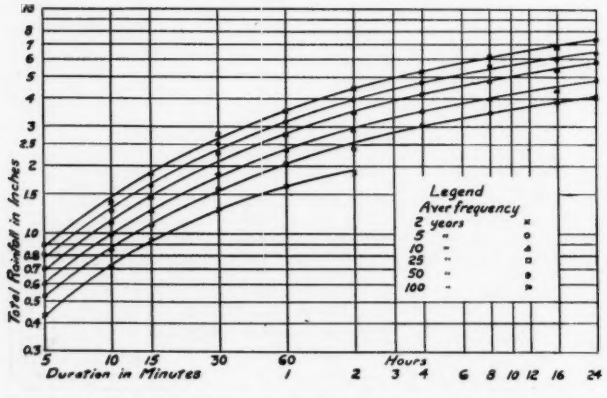
$$Q = C\,I\,A$$

in which Q = the rate of runoff in cubic feet per second
I = the rate of rainfall in inches per hour
C = the runoff coefficient
A = the drainage area in acres.

The first variable mentioned is C, the runoff coefficient. Until C. E. Ramser made his runoff studies in 1917-18 we had little information on the proper values of the runoff coefficient to use for agricultural areas. The only coefficients we had were for impervious areas as given in various textbooks on sewer design. Mr. Ramser in his bulletin, entitled "Runoff from Small Agricultural Areas," Journal of Agricultural Research, vol. 34, no. 9, May 1, 1927, gave us the first reliable data on the proper coefficients to use for agricultural areas. We need, however, much additional information on this important factor. It is possible for the USDA Bureau of Agricultural Engineering through its runoff investigations on agricultural areas *(Continued on page 391)*

Presented before the Soil and Water Conservation Division of the American Society of Agricultural Engineers at Chicago, Illinois, December 1935.

Author: Senior drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. ASAE.



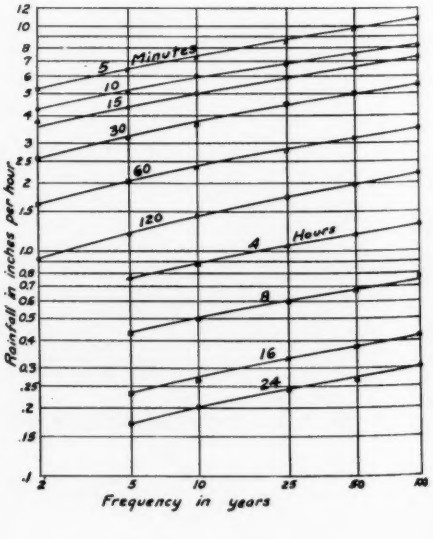


FIG. 1 (ABOVE) FREQUENCY OF INTENSE RAINFALL AT BETHANY, MO. FIG. 2 (RIGHT) FREQUENCY OF INTENSE RAINFALL IN INCHES PER HOUR AT BETHANY, MO. (DATA IN THESE CHARTS TAKEN FROM USDA MISCELLANEOUS PUBLICATION NO. 204)

Adobe Construction

By Harold C. Schwalen

IN THE hot southwestern portion of the United States it was only natural that the early types of homes or building construction should be those indigenous to the country by reason of availability of material and climatic conditions. Native soil, augmented by brush and timbers where available, has been since prehistoric time the principal construction material in practically all of the arid and semi-arid countries of the world.

The use of earth as a building material in the form of sun-dried brick, or adobe, as it is commonly known in the building industry in the Southwest, probably was introduced from Spain. Under Spanish, and later under Mexican influence, it became the common building material throughout the entire southwest border region extending from the valley of the Rio Grande to the Pacific Coast. That the inherent weakness of adobe in its low resistance to the action of water was early recognized, is shown by the use of burnt brick or masonry in the repair of foundations and in the use of burnt brick in the exposed portions of the walls of many of the buildings.

The older section of Tucson, Arizona, provides many interesting examples of adobe construction. Many of the more substantial adobe homes built fifty or sixty years ago are still in use. They are, as a rule, the typical flat roofed, rectangular, L or U-shaped adobe houses with plastered exteriors. Exterior walls are from 18 to 24 inches thick and interior walls have a minimum thickness of 12 inches with ceiling heights of seldom less than 11 or 12 feet. They are usually built on rock masonry foundations which extend about a foot above the ground surface. The flat roofs, covered with earth, have been replaced with galvanized iron, wood or composition shingles, or built-up paper roofs. In many cases the later roofs were of the gable or hip-roof type, with overhanging eaves, and built on top of the old parapet walls. The old outlet pipes, or canales, for carrying rain water through the parapet walls, although no longer used, may still be seen in place on many of the buildings.

The buildings of this type which are still in use represent the highest class of adobe construction of that period. As with all adobe construction, it is apparent that one of the principal difficulties then, as now, was protection of the adobe walls from washing, and from disintegration at the foundation line. Most of these old houses show that repeated plaster repairs were made and new stucco coats applied from time to time. At the foundation line repairs were made with brick or rock fragments laid in lime or cement mortar where the adobes had melted away.

Foundation settlement, although present to some extent in most of the buildings, is less apparent than in many of the newer buildings of adobe. This is probably due to the fact that the older adobe buildings constructed upon poor foundations have long since disappeared. Plaster repairs reveal the presence of cracks in the wall due to unequal foundation settlement, usually near the corners, and likewise over openings where lintel construction was inadequate for the load imposed upon it.

Extensive development of irrigated agriculture in southern Arizona, with the accompanying influx of new people, bringing with them new ideas as to building types, resulted in some deviation from the original flat-roofed adobe structure. The 11 and 12-foot ceilings of the better types of the older buildings were retained, and also the heavy adobe walls, in many cases 18 inches thick. But, on one or two sides, and sometimes on all four sides, open or screened porches were added. The entire structure was then covered with a gable or hip roof, having composition paper or wood shingles, and with overhanging eaves projecting from 2 to 2.5 feet beyond the walls. During the summer months the porches became in reality both the living and sleeping quarters for the entire family. Considered from the standpoint of utility and economy alone, it is doubtful whether any of the later building types are an improvement over this, or even equal to it.

Changing conditions and higher standards of living have modified housing conditions on the farm. The modern farm home now demands equipment and conveniences far beyond the early requirement of four bare walls and a roof. Cost of farm housing has increased proportionately. Exterior appearance and the permanence of construction should be commensurate with the added costs of interior finish, equipment and furnishings.

Present architectural tendencies are to return to the single-story, flat-roofed Mexican type; the Pueblo or Santa

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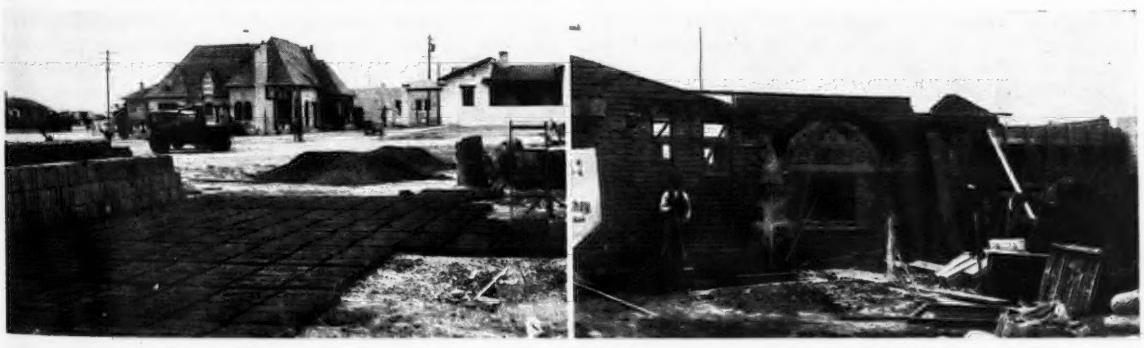

FIG. 1 (LEFT) ADOBES WHICH ARE ABOVE AVERAGE IN UNIFORMITY AND STRENGTH, HAVING BEEN MADE OF SPECIALLY SELECTED MATERIAL. EQUIPMENT USED IN THEIR MANUFACTURE INCLUDES ONLY A WHEELBARROW, SHOVELS, AND HOES. FIG. 2 (RIGHT) AN EXAMPLE OF THE USE OF BRICK MASONRY ABOVE THE FOUNDATION AND AROUND OPENINGS

Fe type, with or without the extended beams or vigas; and the Spanish or Mediterranean type, with red-tiled roofs. Patios in conjunction with arcaded porches, colonades, ramadas, or pergolas are usually associated with the more pretentious of the above-mentioned types. Certainly the architect in the design of the larger houses of these types has ample opportunity to develop pleasing exteriors along simple lines which blend naturally in with the surrounding desert.

The preceding remarks, as well as those which follow, apply more directly to house construction than to general farm building construction, since the former constitutes more than 80 per cent of the farm use to which adobes are adapted. The use of adobe for certain farm buildings, such as dairy barns, poultry houses, and hay barns, is not particularly recommended, and many farm buildings required in a colder climate are unnecessary in the Southwest.

MATERIALS FOR MAKING ADOBE

Suitable material for making adobes is found in practically all agricultural sections, although it may be necessary to use admixtures of either coarse or fine material to secure adobes of highest quality. With the exception of the very small cost of forms and straw or other binder material, the labor constitutes the entire cost of ordinary adobes (Fig. 1). In southern Arizona the labor for making adobes may be contracted for at about $20 per thousand where no special precaution or care is required in mixing the adobe mud. However, all losses due to breakage, or from rain or other causes, are charged to the owner. They should be protected while drying, for carelessness in this respect may result in heavy losses from rains.

From the standpoint of architectural effects, design, and structural details, the adobe may be considered as a substitute for common brick, but inferior to it in several respects. Its compressive strength is 20 to 25 per cent of that of common brick. The minimum compressive strength of adobes should not be less than 300 pounds per square inch, and it probably will not run higher than 500 pounds per square inch. Strength of adobes in tension is so low that no allowance is usually made for it in the design of buildings. Adobes have very little resistance to the washing action of rain, and disintegrate rapidly when wet.

Use of bitumuls, a special emulsified asphalt product, mixed with the adobe mud as an agent for stabilizing adobes against the action of water, has been reported upon favorably by some contractors. The stabilizing agent must be thoroughly mixed with the mud. Use of a concrete mixer has been recommended for this purpose. Locally, the product has not been in use long enough to make a thorough test of its value for this purpose. The additional cost when purchased in small quantities and applied in accordance with the recommendations of the manufacturer, will amount to at least $40 or $50 per thousand for 3½x12x18-inch adobes. The bitumuls has been used locally, however, in smaller quantities such that the cost to the individual builder has not been more than $20 per thousand additional.

Because of the low strength of adobes, a minimum wall thickness of 12 inches is recommended for one-story buildings, and where walls are not braced by partitions, the use of pilasters, at intervals of not more than 12 feet, is suggested. Most of the older adobe walls, still standing, have a thickness of 18 inches or more. Only adobes which have been thoroughly cured should be laid in the wall, as the use of green adobes may result in some settling of the wall in drying. Shrinkage of the adobe mortar joints is reduced as much as possible by the addition of sand to the ordinary adobe mud.

Footings and foundations for adobe structures should be ample in size, bearing in mind that the weight which is carried is about 50 per cent greater than that of the ordinary 8-inch, or 13-inch, hollow, brick wall of the same height. There are so many examples of corners of adobe buildings settling that it should be a common practice to increase the relative bearing area of the footings at the corners. The corners actually carry more load per unit area than the rest of the wall due to the usual practice of locating windows near them. Saturation of the subsoil under the corners is also more likely to occur since the movement of water is from two sides. It is suggested that the inside of corner footings be filled in to provide additional bearing area. This is believed to be especially important where irrigation water may be run close to the building.

The addition of a continuous reinforced concrete plate, at least 6 inches thick around the entire building, should be incorporated in all of the large adobe structures, and is recommended for the smaller adobe buildings of permanent nature. This to a large extent relieves the adobe wall from side-thrust of roof loads. In some cases a continuous reinforced concrete lintel is used instead of plate, to tie the building together.

Lintels over doors and windows should be of sufficient size to carry the entire wall and roof load over the openings, since the adobes cannot be depended upon for any arch action, as is assumed in the case of brick construction. They should also extend a minimum of at least 12 inches beyond each end of the opening to insure adequate bearing area on the wall. Shrinkage in the mortar joints is taken care of by allowing clearance of about one inch between the lintel and header.

Special care should be exercised in the setting of window and door frames in adobe walls. Door jambs in particular should be firmly anchored to the wall. One method is to nail a 2x4-inch fin to the back of the jamb and build the adobe courses up around it. In some cases, special shaped adobes are made to fit closely around the door or window frames. Nailing blocks of various types are often used, but care should be taken that they are securely anchored in the wall. Another common method in the better types of construction is to use brick around all openings, in arch construction, and for several courses above the foundation, as shown in Fig. 2.

INSULATING VALUE OF ADOBE

The insulating value of adobe lies chiefly in the thick-walled construction, since its specific heat and conductivity are practically the same as those of soft-mud, common brick. In order to utilize this insulating value, the size and number of openings should be limited. This is especially true for those on the east and west sides of the building. Likewise, window and door frames should be set near to the inside of the wall so that they are somewhat protected from the direct rays of the sun. The above recommendations apply particularly to those sections of the country where the days are hot and the nights are cool; where the general practice is to keep the house closed during the daytime and open at night. In southern Arizona the plan works fairly well, in so far as keeping the house cool during daytime is concerned, but in the early evening the house is comparatively warm. The adobe walls cool slowly, and their massive construction is then a disadvantage because of the large amount of stored heat which must be dissipated. The result is that outdoor sleeping quarters are much in use.

Ceiling and roof construction in adobe buildings differ but little from that of other types of buildings. Special care should be taken that the adobe walls are not subjected

to side thrust from roof loads, because of the weakness of these walls. Unplastered adobe buildings should have overhanging roofs for protection of the walls from rain, or in the case of parapet or patio walls, they should at least be protected with a cement or brick coping.

Interior walls of adobe houses are unsatisfactory unless plastered, and the ordinary gypsum plaster is used with fair results. Less difficulty with loose plaster is experienced than on the outside walls.

The general practice is to plaster the exterior of adobe walls, for protection against the washing action of rains and disintegration at the foundation line. Difficulty is experienced in getting a waterproof plaster to adhere to the adobe wall. Apparently better success is had in using a lime-cement scratch coat, and in succeeding coats decreasing the percentage of lime content. Of the many methods used to secure a permanent plaster job on adobe the following appear most successful:

1 The use of metal lath or one-inch-mesh chicken wire nailed securely to the top and side of the wall, results in a reinforced plaster sufficiently rigid to stand even though not firmly bonded to the adobe.

2 Nailing the entire exterior of the wall with eight or ten-penny nails, three or four to each adobe, leaving about ¼ inch of the head end exposed, but countersunk in a hole made with the hammer for each nail, serves to key the plaster to the wall.

3 Raking out the mud mortar from the joints to a depth of 2 or even 3 inches and chinking fragments of brick or small rocks with lime mortar in the openings, requires much labor but was successfully used on many of the old Mexican homes.

4 Adobes may be laid with lime mortar, leaving intentionally rough joints, to form a bonding surface for the plaster.

5 Special keyways may be cast in adobes when they are made to provide a mechanical bond for holding plaster to the wall. In ordinary adobes two vertical keyways are made about ¾ inch wide and about the same depth. Small adobes made in the ordinary wire-cutting brick machine may have horizontal keyways cut in the side for the same purpose.

All of the above methods are an added expense in the plastering of adobe walls, but to apply a plaster coat to the adobe without special precautionary methods usually results in waste of both the material and time used in applying it. Material required for plastering adobe walls will run from 50 to 100 per cent more than for brickwork, depending upon the roughness of the walls. The labor cost of plastering is likewise somewhat greater.

Adobe mud plaster has been used but little in recent years for either interior or exterior plaster in Arizona. An interesting experiment is being made by a builder near Tucson, Arizona, in which the mud plaster mixed with a small percentage of bitumuls, is used for exterior plaster. It presents the soft natural adobe color which is so often desired, but its permanence is as yet unproven. The inside plaster has been painted and cannot be distinguished from the ordinary painted-plaster wall surface.

Painting of exterior walls has been practiced to only a limited extent. The adobe absorbs large quantities of paint or oil and it does not appear to provide effective permanent protection. At present its use cannot be recommended, except possibly on walls partially protected by overhanging roofs.

In adobe the farmer or rancher has a satisfactory building material for the construction of farm buildings at reasonable cost. With an understanding of the characteristics of the material, and a knowledge of the special precautions necessary in adobe construction, its use is warranted in the better types of house construction. The cost of first-class adobe construction in urban districts is comparable with that of brick construction, but for the isolated rancher its use will result in a considerable saving. The extent to which the builder should go in following the suggestions which have been made is governed by the purpose for which the building is constructed and by the permanence desired.

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Discussion by J. D. Long

THE SUBJECT of adobe construction had its introduction into the deliberations of this Society just ten years ago, the term "adobe" being defined as any method of construction whereby natural soil was incorporated into walls.

Early studies were directed at historical and use surveys, and observations of limitations and advantages. Recent construction which has come in for critical examination has confirmed, in examples too numerous to be accidental, the premise drawn from older examples, that natural soil can be used successfully for many types of structures and under varied climatic conditions.

Gradually an appreciation of the technicalities of the subject has developed. In common with all other building materials adobe has its characteristic merits and its weaknesses. It is only sound engineering procedure to determine its peculiarities and limitations as a basis for recommendations governing its use.

During the past two years popular interest in the subject in California has markedly increased. This is doubtless due in part to its use on a number of emergency labor relief projects, where its use was in turn predicated to a large extent by the relatively large unskilled labor requirement.

The agricultural significance of this trend is marked. Small-scale farmers and agricultural laborers on the relief roles are being trained in this form of construction, and others are being given visible examples of its use. For the most part, these examples of use are good, the work is well conceived and the project well designed. We can expect that a larger number of small builders than ever before will be favorably inclined to consider the merits of this construction for their own building projects.

We can also anticipate that the publicity given these various projects, the more numerous examples of well-executed work, and the development of a number of small contractors promoting the work will influence a certain number of more substantial builders to select this material. It does not seem likely, however, that the total amount of this type of construction will reach a significant figure,

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(LEFT) ADOBE BRICK COTTAGE IN COTTON PICKER'S CAMP. (CENTER) FOREMEN'S COTTAGES OF SAME CONSTRUCTION ON ALAN HOOVER'S "GREENFIELD RANCH," BAKERSFIELD, CALIFORNIA. (RIGHT) AN ADOBE BRICK "MOTEL", BAKERSFIELD, CALIFORNIA

except in individual communities where aggressive adobe builders develop the field.

One of the most interesting of the work relief projects in California is the Brawley city hall in Imperial County. This structure, valued at $50,000 and completed in June 1933, was promoted by Mayor R. L. Baker, and replaced a city building destroyed by fire. The labor was secured from those owing long delinquent water bills and taxes to the city, a system of scrip being devised so that merchants and others not employed directly on the project could participate in the relief measure.

Other recent projects of a public nature include federal and county labor relief and public service offices and work rooms; federal and state forestry department residences, offices and shops; county fair ground exhibit buildings and stables; state park and CCC camp buildings; airport administration buildings; and a state highway beautification project of historical background.

Some communities in the warm valleys of the state have turned to adobe construction for an appreciable portion of the residential construction, because of the attractive thermal characteristics of such walls under the local climatic conditions. The construction has been used also in cooler areas, even for beach cottages, presumably for sentimental or economic reasons.

Technical Progress. An enumeration of the technical advances in the art of this construction may logically start with the studies dealing with the suitability of the soil for this purpose. The work of Patty at South Dakota State College and Schwalen at the University of Arizona have been significant contributions, but there is still much to be determined before the engineer will have sufficient data to enable him to use this material as unerringly as the standard materials of commerce. The attention being devoted to soil physics studies by engineers interested in soils as foundation material will undoubtedly contribute to this associated field.

A concept of the soil as a 3-phase composition, a cementing material and two inert aggregates (clay, loam, and sand), has indicated possible parallels with certain design theories for portland cement and asphaltic concrete mixes. The variable characteristics of the clay, and particularly its colloidal fraction, have not yet been sufficiently studied to permit a well-organized conception of types and properties when in puddled condition. Much of the recent analytical work, particularly that of certain commercial interests, has ignored the silt as a separate phase in grouping all material passing 200-mesh screens. It is doubtful that this procedure can give as valuable results as one indicating a finer division of the soil material.

A very interesting phase of the study still largely in the offing is the treatment of soils in which the clay or colloidal fractions are extreme, possibly by chemical flocculating or deflocculating agents. The general preference expressed by most present-day Mexican adobe brick makers for horse manure as a binder in their mud mixes may arise by reason of a corrective action of the dilute ammonia in the mix, on the soil fines. The effect of various concentrations and types of soil alkali on both the structural condition of the puddled soil and on wall finishes is still to be determined.

Admixtures of asphalt with the soil have been tried for several years, and at least one hot-mixing plant has been erected in California for the commercial manufacture of impregnated adobe brick. Within the past two years an accidental discovery has led to the mixing of a selected grade of cold asphaltic emulsion with the mud mix. Used at a suggested optimum of 15 per cent, based on the 200-mesh soil material, tests by the U. S. National Park Service credit the final product with 92 per cent efficiency in waterproofing. Practical demonstrations, for the most part, have been quite convincing. On the construction of the quarter-mile-long horse barn at the San Joaquin County Fair grounds the foundation trench was filled with storm water against the recently built wall, and later, after the completion of the structure, the walls were inundated 18 inches by flood waters, without apparent damage either time to the stabilized brick walls. There are indications, however, that intensive sunlight has a deteriorating effect on horizontal surfaces of the stabilized material.

For the normal range of soils suitable to adobe construction and the prices currently quoted, the asphaltic stabilizing material adds a material cost of $40 to $50 per thousand for the standard 4-12-18-inch adobe brick. Adobe brick contractors appear to favor increasing their labor charges 20 per cent to cover the additional trouble involved, making a total cost of about $140 per thousand for the stabilized brick laid in place in the wall, in stabilized mud mortar. Since about 3,000 bricks are required for the exterior walls of a compactly planned five-room house, the extra cost for the stabilized brick in such a structure amounts to approximately $180.

To offset this additional cost it has been suggested that no protective exterior wall coating is required, and that the stabilized mud material may be used for foundations, for basement floors and walls, for subfloors over solid fill, for an insulating fill over flat roofs and for parapet wall capping.

Recommendations for the use of the stabilized material on any adobe construction project must be based on the exercise of an economic valuation of its advantages. The possibilities are sufficiently striking, however, to nominate the procedure as one of the outstanding recent technical developments in this field.

Structural Design. Another outstanding technical advancement has been a rather general agreement on the maximum and safe design stresses for adobe brick work, and a concession by some civil engineers and architects that working to these stresses is possible and deserving of consideration.

Special regulations formulated by the Federal Housing Administration in California, and governing loans on adobe brick construction, specify that applications must be accompanied by a competent laboratory test showing maximum

UNIT STRESS VALUES
(Specimens puddled from wet mixes, adobe brick)

Stress	Ultimate pounds per square inch	Allowable pounds per square inch
Compression	350	35
Shear	40	4
Tension	110	0
Flexure	75	0

unit compression and shear values, and by a design analysis showing the maximum stress values induced in the structure, which shall not exceed those shown in the table. Further, it is specified that buildings in general are to be restricted to one story, or, with special provision, to two low stories; that roof framing must be designed to avoid lateral thrusts; and that the design must meet the state law and any local regulations relating to lateral stress. The code concludes: "A competent architect will find no difficulty in meeting these requirements . . . . . ."

Integral reinforcement of adobe walls has been shown to have a definite structural value. An early requirement of the FHA of vertical wire ties at 6-foot spacing over the face of the wall, between concrete foundation and top plate, would appear to be of questionable value, however. The subject deserves further investigation and consideration on some of the larger scale projects.

Improvements in Methods and Equipment. Since this type of construction appeals primarily to small-scale contractors or self-builders, it is unlikely that improvements requiring additional expenditures will find ready acceptance. Patty's work on pise' characteristics, as to water-mix relationships, and painting to retard drying and surface crazing, are outstanding technical improvements.

The adaptation of concrete and plaster mixers and the development of special presses for both the sun-dried and pise' brick, the latter including a conveyor to the wall for immediate laying, all indicate noteworthy attempts of individual contractors to expedite the work.

Insulation Value. Dean Milton of the New Mexico State College has completed tests of the insulation value of adobe which "show adobe to rank as one of the best insulators." His data may be summarized as $V_a = 0.281$ for an 11-inch wall, and 0.1825 for a 16-inch wall with plaster and stucco, and the average conductance, $K = 3.58$. It would appear probable that both the soil texture and density of the puddled material would affect these unit values.

The relatively high heat capacity of the thick adobe walls is a factor of as much consequence as the conductance in evaluating the living comfort of adobe houses. For the central valleys of California where the summer diurnal range is 40 to 50 degrees (Fahrenheit) the house interior-temperature lag smooths out the extremes in a most desirable manner. For localities where the temperature does not drop appreciably with the setting sun, it will be conducive to sleeping comfort to design the bedrooms in a wing or on the second floor of the adobe house, building them, however, of a more readily cooled wood-frame construction.

The winter insulation effects are, naturally, the converse of the summer.

Any study of the "overall" insulation effects of adobe construction should include the factor of heat radiation to and from the walls to secure a true index of their "comfort value."

Surface Finishes. The practice of exposing the natural wall texture on both interior and exterior is growing in popularity. To harden and waterproof the surface two or more brush coats of fuel oil with an appreciable asphalt content, fish oil, linseed and tung oil, or paints using the latter two as vehicles, are variously recommended. Cold water paints give attractive, soft-textured finishes over a waterproof base course, but are relatively short-lived. Various proprietary finishes have been used with differing degrees of success.

It is an interesting commentary that so much still remains to be learned relative to the utilization of what is undoubtedly the oldest building material to be used by man.

Application of Rainfall Intensity-Frequency Data

(Continued from page 386)

and for the Soil Conservation Service through its erosion studies to collect such information. Hence these bureaus as well as other agencies, such as the water resources branch of the U. S. Geological Survey should cooperate in getting such data and making it public.

The second variable, time of concentration, although not mentioned directly in the rational formula nevertheless is very important, as we must know it before we can determine the value of I, the rate of rainfall in inches per hour to be used in the formula. The maximum discharge to be expected from any watershed for a given frequency will occur only when the storm over the entire area is of a duration sufficient that all parts of the watershed are contributing to the flow at the outlet. This duration or time of concentration must be determined for a watershed before the USDA intensity charts can be used.

Mr. Ramser in his bulletin determines this time, with certain modifications dependent upon saturation and other factors, as the time required for the water in the channel to rise from the lowest to the highest stage. In making computations we may not have such data, hence we must compute the time it takes for water to travel from the remotest part of the watershed to the point at which we desire to determine the amount of runoff. This requires a knowledge of the size, shape, and topography of the watershed. Mr. Moyer's method of determining time of concentration takes into account the ratio of area-length and area-breadth.

How much can the time of concentration vary for a given watershed? It is not necessarily a constant but may vary to some extent depending upon the season of the year, vegetation, and other factors. Additional information on this subject is highly desirable and the agencies previously mentioned are able, with little additional effort, to get such data.

The third factor is the possible construction of flood-frequency curves from the USDA rainfall charts. If we know for a given watershed the proper runoff coefficient to use in the rational formula, and the time of concentration for this watershed, we can prepare a flood-frequency curve. After computing from the intensity charts the maximum discharges for frequencies of 2 to 100 years, one may plot these values with frequencies as abscissa and discharge as ordinate, and a flood-frequency curve will be obtained. Unfortunately our records of actual discharges from small areas usually are not of sufficient length to prepare a reliable flood-frequency curve by the probability method.

It should be remembered that the rainfall intensity-frequency charts shown in the USDA bulletin, as predictions of future occurrence, are probabilities rather than absolute certainties. Only as the length of our rainfall records approaches 100 years will the correctness of the charts be revealed.

The Storage of Corn Fodder or Stover

By E. A. Silver

DURING the past few years several requests have come to the Ohio Agricultural Experiment Station for information relative to the matter of chopping corn fodder and stover for mow storage. This practice, although not yet common in Ohio, has become quite prevalent in some of the other central and western states.

In order to determine the behavior of chopped corn stover in the mow an experiment was started on the farm of Stanley W. Peet, Richwood, Ohio. The material was stored in one end of a 36-foot-wide mow. The average depth of the chopped feed was approximately 12 feet and 37½ tons of chopped corn stover were stored with 2 tons of chopped corn fodder placed on top. Only a small part of the mow was required to store the 39.5 tons of chopped material.

Due to the fact that the stover had remained in the field over winter, it was not of the best quality. At the start of operations it was dry, but before the first day's run was completed a heavy rain fell, bringing the moisture content of the material up to 30.2 per cent. Rain fell again on May 2 and 3, and kept the material to a high moisture content. The following days, up to May 12 and 13, were without rain. Filling operations were completed on May 9. Three samples taken on May 12, 15 and 19 were secured from the top of the pile and after chopping operations were finished. This was done to determine if water condensed at that point. This was found to be true, but not to any great extent. The average moisture content was approximately 21 per cent. Perhaps if it had been a little higher a better cure would have been obtained by a resulting greater fermentation.

Until further experiments can be conducted to determine a maximum moisture content for safe storing conditions, no definite recommendations can be made on storing hay, fodder, or stover with a higher moisture content. Maximum moisture content will depend a great deal on outside weather conditions and the degree to which the material is sealed on the outside of the pile by mold or other means.

The machine used to chop the stover was a combination knife-and-plate roughage mill with a cylinder cutterhead. This mill also has a recutting bar. A screen is located around the cutter head to retain the larger pieces to be recut. With this construction, it was possible to reduce the material into short, uniform lengths and to cut the butts of the stalks into uniformly small pieces, thereby promoting release of moisture and ability to form a compact mass without resorting to pressure. The length of cut was 3/16 inch.

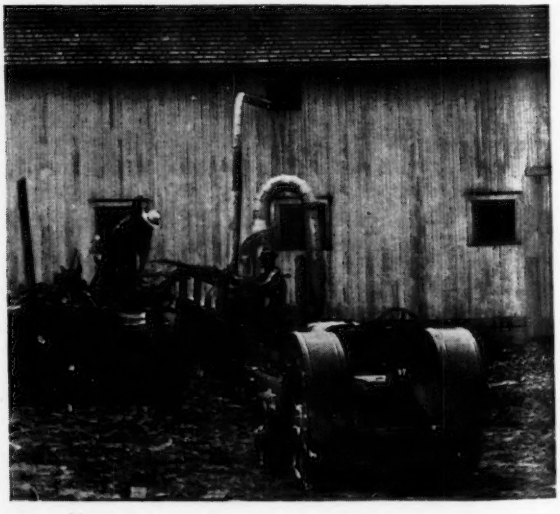
This mill was also equipped with a grain separator, whereby the light roughage cuttings are drawn off by suction created by the fan. The roughage is, therefore, not ground, but only chopped. The grain falls by gravity from the bottom of the separator tank and is ground separately. It can be sacked directly from the machine or returned and mixed in with the chopped roughage in the same operation. From previous engineering tests at this station, corn stover can be chopped and the grain ground by this machine with an increase of 30 per cent in capacity and a saving of 12 per cent in power, compared to cutting and grinding. In these tests the grain separator increased the operating efficiency of preparing corn fodder 46 per cent.

In this experiment, the machine was located at a convenient place beside the barn for the delivery pipe to enter the mow. The pipe was placed along the mow floor with an elbow at the delivery end of the pipe set upward at approximately 45 degrees from the mow floor. Less power will be required if the horizontal pipe slopes downward a little toward the delivery end.

The chopped roughage was blown against the rear wall of the mow from the end of the pipe to a height of approximately 30 feet. This allowed the material to fall by gravity to the mow floor and to maintain a uniform mixture of light and heavy particles. This is important both from the feeding and keeping standpoints. No tramping was done. The pile of chopped feed was allowed to settle by its own weight. From our experience with chopped hay, tramping is apt to lead to much spoilage of the material.

In order to determine the behavior of the chopped stover and fodder, careful records were kept of temperatures from the time it was placed in the mow until the temperatures began to show a definite decrease. The instrument used for this work was a potentiometer with a set of thermocouples. A low set of six wires were placed 5 feet from the floor and 6 feet from each other and from the sides and end of the mow. Two other thermocouples were placed 9 feet from the floor and approximately above the center of the delivery pipe. Readings were taken regularly three times daily when the temperatures were on the increase. After the peak temperatures were reached, readings were taken only once daily, and later every third day.

The peak temperatures occurred approximately on the third and fourth days after the material was placed in the mow. Although several factors *(Continued on page 394)*



CHOPPING FODDER FOR STORAGE TEST ON STANLEY W. PEET FARM, RICHWOOD, OHIO, WITH A LETZ ROUGHAGE MILL WITH SEPARATOR

Author: Research agricultural engineer, department of agricultural engineering, Ohio State University and Ohio Agricultural Experiment Station. Mem. ASAE.

New Developments in Terracing in the Southeast

By M. L. Nichols

IT HAS been my privilege during the past year and a half to study terracing and other erosion control measures throughout the Southeast, to confer with many of the leading thinkers of the region on erosion control problems, and to assist in the planning of extension and research programs. In this paper some observations of these studies are presented to indicate trends in engineering practice and thought, rather than to give specific technical detail.

A brief glance at the general situation in the Southeast may be of interest. At present a coordinated attack is being organized by all branches of agriculture, largely as a cooperative enterprise between the Soil Conservation Service of the U. S. Department of Agriculture and the land-grant colleges and associated agencies representing the states. Rather complete programs of erosion control are being set up for the individual states by state advisory committees which generally consist of the directors of extension, the directors of the state experiment stations, and the state coordinators. The programs are in a large part set up to function through cooperative associations of farmers. These associations in the past have been organized principally for the purpose of purchasing and operating large-size terracing equipment. At present they are expanding their activities into more complete control programs. In some states laws creating soil conservation districts have been passed and they are being considered in others. These will permit the formation of legal districts for soil conservation, much as drainage districts were organized in the past.

COOPERATIVE TERRACING ASSOCIATIONS

Another stimulating and far-reaching influence on erosion control is the new domestic allotment amendment to the Soil Conservation Act. The administrators of this act have authorized the payment of as much as two dollars per acre to farmers for terraces. Many farmers who have been unable to get their terracing done in the fall and winter, are planting strips of grain across the fields on lines laid out for terraces. This will permit the continuous operation of tractor outfits during a large portion of the summer. In many places where the soils are hard and dry, road rippers will be used to prepare the ground for the terracer. The total amount which can be paid the farmer for this purpose is entirely inadequate as a basis on which to finance large cooperative equipment, and other means of financing the associations are being sought. The development of the terracing program has, however, progressed with such rapidity that the great need at present is the educational and supervisory support for field operations which is necessary to put the associations on a sound business basis. This service is being organized cooperatively between the Soil Conservation Service and the Extension Service.

Presented before the Soil and Water Conservation Division of the American Society of Agricultural Engineers, at Estes Park, Colo., June 1936.

Author: Regional engineer, Soil Conservation Service, U. S. Department of Agriculture. Mem. ASAE.

In general the terraces found in this region may be divided functionally into three distinct classes, namely, the absorption type, the drainage type, and what, for want of a more descriptive word, we call the "filter-strip" type. The first is characterized by level mounds calculated to hold the water on light absorptive soils until it is absorbed or percolates through the soil itself. The second or drainage type consists simply of channels produced by levees or ditches placed across the slope to intercept runoff before it accumulates into dangerously large quantities. Concentration of water is a necessary result of this function. The filter-strip type may be best described by one method of its formation. In many sections strips of sod were planted on approximate contours in furrows across the field. As the sod grew it caught up or filtered out the coarse aggregates of soil and bound them together with living roots. These structures gradually developed into bench terraces, materially aided in many cases by reversible or two-way plows. Rocks, stones, and, in some cases, logs were used to start and develop these benches. Many kinds of plants grew on them but perhaps the most effective was the native honeysuckle. This type of terrace in general is adapted to slopes too steep for absorption or drainage types. All kinds of combinations of these three types may be found.

An understanding of the functions of these structures provides the basis for proper design to meet the requirements of soil, climatic factors, and cropping practices; and provides the only logical basis for engineering practice. Strangely enough, while these factors are apparently generally recognized by engineers and soil technicians, I have been unable to find quantitative and specific measurements of soil properties or any very specific information on absorption by various structures on which to base engineering calculations. To remedy this condition rather extensive field studies are being jointly planned by the Soil Conservation Service and the southern experiment stations. It is hoped that these studies will provide a basis for terrace design for that region.

INCREASED EMPHASIS ON CHANNEL CAPACITY

Possibly one of the outstanding changes of viewpoint among those interested in terracing in the region is the new emphasis which is being placed on channel capacity. Formerly the characteristics by which a terrace was described were the height and width of the mound. Undoubtedly this is of considerable importance when absorption is the major objective, but when the structure is primarily an intercepting, low-velocity channel, capacity is of paramount importance.

During the last winter very unusual conditions prevailed throughout the South. In Mississippi B. L. Taylor and H. L. Palmer had set devices in terrace channels to measure depth of flow. Later the ground froze solid and a heavy rain, over seven inches, fell in a very short period of time. Under these unusual conditions the actual cross section of channel needed, using Ramser's grades and spacings, was shown to vary from 3 to 7 square feet, the average being about 5 square feet. From this it was esti-

mated that under ordinary conditions 5 square feet was ample for a minimum capacity. F. E. Hardesty and the author, at the Athens project, studied the construction of variable-grade, drainage-type terraces and succeeded in producing a standard terrace having about 8 square feet of cross section in four rounds, when using a standard 40-hp outfit on Madison soil. This modification of construction, first suggested by Hardesty, leaves an easily crossed, flat channel about 5 feet wide. Taylor, Palmer, and the author, using similar procedure on Kerwin soil at Meridian, Mississippi, obtained over 10 square feet with the same number of rounds. On the Cecil soil at Spartanburg, South Carolina, McAlister and Dyer obtained about 8 square feet with seven rounds. In these terraces the soil was all moved down hill. Studies conducted at the Dadeville project by the united staffs of the Alabama Agricultural Experiment Station and the Dadeville project showed clearly that but little actual effectiveness was added to the terrace by any of the soil thrown up from the lower side. With proper manipulation of the equipment, the lower side of the terrace may be so gently graded that the terraces are scarcely noticeable when looking up the slope. It should not be overlooked in this connection that this procedure cuts the cost to approximately one-half in many cases. Where this procedure is being followed, cost records, which include Soil Conservation Service engineering overhead, the employment of skilled engineers in planning the field and laying out the terraces, construction, depreciation of equipment and repairs, and checking the terraces, show an outlay of slightly more than $3.00 per acre. In some cases the cost is below $2.00 per acre, on terraces which are spaced to give 8 or 9 acres per mile.

Frequently, in engineering practice, the failure of structures provides the starting point for improvement. In the expansion of the Soil Conservation Service operations into the coastal plain, specifications found to be satisfactory in the Piedmont and Middle West were issued to engineers. In one case studied by myself variable-graded, levee-type drainage channels were used, having a maximum grade of 4 inches per 100 feet. In the heavy rains of the winter the entire outlet channels were in many cases transformed into gullies despite the fact that mechanical structures had been carefully placed in them according to the specifications found satisfactory in other localities. A study of the soil conditions led to an entire change of specifications, using absorption terraces with a variable grade, as a safety factor, of not to exceed 2 inches per 100 feet. Vegetative outlets were provided. Studies of other outlet failures of a similar kind leave the author of the opinion that the entire program of engineering for erosion control for this area must be revamped and based upon studies of soils and vegetation if either economy or reasonable security is to be attained.

The entire question of outlets for terraces is one that is far from solved. In the first place, the majority of structures which have proven themselves in many sections of the United States having much grass, gentle slopes, absorptive soils well held together with organic materials, and low rainfalls, are not economically feasible on the poorly vegetated steep slopes, small fields, and lateritic or semi-lateritic soils of the Southeast. An attempt has been made to meet the cost of these structures by concentration of larger quantities of water into one outlet, but this apparently only intensifies the soil physical problems involved. Probably the correct answer is scattering the water and trusting to vegetative control. Numerous experimental vegetative outlets, such as meadow strips, are being constructed and, while these in the lower South have been in operation for only a year or less, the present indication is that they are very close to a practical answer to the problem.

Another problem of considerable importance in the deep South is that of turning under cover crops grown in the winter to protect the land and furnish nitrogen in the spring. One manufacturer has designed and is producing a heavy-duty harrow for turning under cover crops, which is so constructed that the rear section may be reversed and the harrow used for cleaning out the terrace channel. This harrow has rubber-tired transport wheels so attached that the harrow may be readily moved on the highway, a necessity for community equipment. An experimental field at Auburn was terraced with an experimental model of this harrow, simply by making a few rounds on lines laid out for terraces. The channel developed was sufficient to protect the field even though the rows of corn were run across the terrace channel.

This statement should not be interpreted as advocating this harrow as a terrace construction implement for general use, but merely that it is exceedingly efficient in maintenance and may be used for construction by large farmers just as the cylinder disk plow was shown to be quite efficient for this purpose a number of years ago.

The general trend of development of the erosion control work in the Southeast is toward a coordinated program in which terracing is considered by all as an important part. The relationships of such structures as terraces, and of soil type, to the general farm program and other factors, is receiving increased attention.

The Storage of Corn Fodder or Stover

(Continued from page 392)

may influence this peak temperature and the time it occurs, the results are comparable to those obtained in chopped hay experiments. Following this peak on the third and fourth days, the temperatures began to drop slowly, with intermittent rises occurring at various times. These rises seemed to depend a great deal upon the outside temperature. There was very little difference between the high and low points, although one of the high wires registered the highest temperature. The results of this work compare favorably with those on chopped hay, although the temperatures in this case were not as high. The maximum for chopped hay was 78 degrees (Centigrade), for chopped fodder or stover 72 degrees.

At the end of two months an examination was made to determine the condition of the material. A slight coat of mold had formed on top and around the exposed sides of the pile. This mold should act as a protection against ignition as it helps to shut off the source of oxygen. A chemical analysis was made on the chopped corn stover, the results of which were as follows: Moisture, 6.20 per cent; protein, 7.45 per cent; fat, 1.65 per cent; fiber, 20.80 per cent; ash, 5.50 per cent. Total carbohydrates, 79.20 per cent. Nitrogen free extract, 58.40 per cent.

Below the layer of mold there was no evidence of spoilage. The unspoiled stover showed light brown color and had a rich odor similar to that of tobacco. Although none of this material has been fed to date (June 25), these conditions were similar to those found in chopped hay which animals relished greatly.

A Method of Measuring Acres per Mile of Terrace and Total Acres Benefited

By V. R. Hillman

ACRES per mile of terrace and area controlled or benefited by terraces have been subjects of quite a little importance to those concerned with terracing. The purpose of this discussion is to suggest a method of determining both the acres per mile of terrace and the actual area benefited by any number and length of terraces in a field or in a system of parallel terraces.

It is generally assumed and it appears to be logical that the area controlled or benefited by a system of terraces is the area between terraces together with one terrace interval above the first terrace and one interval below the last terrace in a series, provided, of course, that the upper terrace is within one standard interval distance from the top of the ridge, or, if not, that the area above that point is controlled by another terrace system or by other means.

Acres per Mile of Terrace. Under the above conditions then, if a field is two terrace intervals wide, one terrace through the center would control the entire field. If the horizontal terrace interval or distance between terraces is 75 feet and the terrace one mile long, then the area above the terrace will be 75 feet times 5280 feet or 9.1 acres. This is the figure "*C*" given in Table 1, which is the area above one terrace one mile long for the interval shown. The total area controlled or the actual acres per mile of terrace would be twice this, or 18.2 acres. If the field is three intervals in width, then it will be controlled with two terraces, and the total area will be 27.3 acres, or 13.65 acres per mile of terrace.

It is obvious then that the acreage per mile of terrace is dependent upon two factors, that is, the horizontal distance between terraces and the number of terraces in the system. The length is of course a third factor and is accommodated in the calculations that follow. Assume a field with six terraces whose total length is one mile and with an average spacing of 75 feet. The area controlled will be 9.1+9.1/6, or 10.6 acres, which in this case is the total area controlled and also the acres per mile of terrace. This can be stated in the general equation of $B = C + C/n$

B = Acres per mile for any number and length of terraces

n = Number of terraces in the field or system

C = Acres per mile from Table 1, or the area above one terrace one mile long.

Another way of stating the same relation is,

$$B = \frac{(n + 1) \times C}{n}$$

which in the above example would be $(7 \times 9.1) \div 6 = 10.6$ acres per mile. This is true for any number and average length and spacing of terraces regardless of whether or not the total length is one mile. Note that it gives acres per mile and not total area controlled, except in the one case where the total length of the terraces is one mile.

Thus, to find the acres per mile for any number and length of terraces in a field or in a system of terraces, multiply C in Table 1 for the corresponding average spacing by one more than the number of terraces and divide by the number of terraces.

TABLE 1. HORIZONTAL TERRACE INTERVAL, OR DISTANCE BETWEEN TERRACES, AND ACRES PER MILE OF TERRACE

Horizontal distance, feet	Acres per mile, C	Horizontal distance, feet	Acres per mile, C	Horizontal distance, feet	Acres per mile, C
15	1.82	27	3.27	39	4.72
16	1.94	28	3.39	40	4.85
17	2.06	29	3.51	41	4.96
18	2.18	30	3.63	42	5.09
19	2.30	31	3.76	43	5.21
20	2.42	32	3.88	44	5.33
21	2.54	33	4.00	45	5.45
22	2.66	34	4.12	46	5.57
23	2.79	35	4.25	47	5.70
24	2.91	36	4.36	48	5.81
25	3.03	37	4.48	49	5.93
26	3.15	38	4.60	50	6.06

NOTE: C = Area above one terrace one mile long for the given horizontal distance. For intervals not shown the table may be interpolated or values combined. That is, for a 150-foot interval, move decimal point one place and read $C = 18.2$. For 75 feet, take one-half of this, or 9.1. For 121 feet, take one-half of C for 200 which is 12.1, plus C for 21 which is 2.54, or 14.64 acres per mile. For 63 feet, add C for 31 and C for 32, or $3.76 + 3.88 = 7.64$. The table may be expanded to give each value directly, but is contracted here for convenience.

To find the actual acres controlled by any number and average length and spacing of terraces, assume a field with six terraces having an average spacing of 75 feet and a total length of 2400 feet. The average terrace length then is 400 feet and the area above this terrace of average length will be $400 \div 5280 \times C$ for a 75-foot interval. The total area controlled by the six terraces is $[(6 + 1) \times 400 \div 5280] \times C$, or $0.53 \times 9.1 = 4.8$ acres.

The general equation is *(Continued on page 408)*

TABLE 2. VALUES OF FACTOR $\frac{(n+1)\,L}{5280}$ IN EQUATION $\left[(n+1) \times \frac{L}{5280}\right] \times C$

Number of terraces on field	Average length of terrace (feet) 200	400	600	800	1000	1200	1400	1600
1	0.76	.151	.227	.302	.378	.455	.530	.605
2	.114	.227	.340	.455	.518	.680	.795	.910
3	.151	.302	.454	.605	.750	.910	1.06	1.21
4	.190	.378	.518	.760	.947	1.14	1.33	1.51
5	.227	.454	.680	.910	1.14	1.36	1.59	1.82
6	.265	.530	.795	1.06	1.33	1.59	1.85	2.38
7	.302	.605	.910	1.21	1.51	1.82	2.12	2.42
8	.340	.680	1.02	1.36	1.70	2.14	2.38	2.72
9	.378	.760	1.14	1.51	1.90	2.27	2.65	3.03
10	.416	.833	1.25	1.66	2.08	2.50	2.92	3.33
11	.455	.910	1.36	1.82	2.27	2.72	3.18	3.63
12	.492	.985	1.48	1.97	2.46	2.95	3.44	3.94
13	.530	1.06	1.59	2.12	2.65	3.18	3.71	4.24
14	.567	1.14	1.70	2.27	2.84	3.40	3.98	4.54
15	.605	1.21	1.85	2.42	3.03	3.63	4.24	4.84

Author: Chief agricultural engineer for Virginia, USDA Soil Conservation Service. Assoc. Mem. ASAE.

What Agricultural Engineers Are Doing

From the BAE, USDA

A FLUME to be used in a study of the hydraulic jump has been built at the University of Iowa. The objects of the study, which will be under the supervision of D. L. Yarnell, are to determine the slope of spillway apron for most efficient jump; the relation of velocities above and below the jump and the height of the jump to the slope of the downstream face of the outlets of the lateral drains, and to the slope of spillways of dams; and the efficiency of the jump on sloping aprons of flood-detention dams and spillways.

* * * *

The month of June, 1936, marked the close of the first year of operation of the CCC drainage camps, the first camp at Bancroft, Iowa, having been opened and occupied by enrollees on June 25, 1935. There are now 36 camps in operation in the Central District. These camps have during the past year performed maintenance work having a commercial value estimated at $3,123,000. A total of 77,770,475 square yards of clearing, 57 miles of tile reconditioning, and 8,017,459 cubic yards of excavation and embankment work, constitute the chief items of work accomplished with an expenditure of 923,761 man-days.

* * * *

During the period of July 13 to 22, a cotton-ginning extension conference and training school was held at the U. S. Cotton Ginning Laboratory, Stoneville, Mississippi. The instructors in the school were the staffs of the Bureaus of Agricultural Engineering and Agricultural Economics, under Charles A. Bennett and F. L. Gerdes. This school was held at the instigation of the departmental office of extension, in conjunction with the state extension forces, during which cotton-ginning specialists and extension engineers were acquainted with the nature of technical and extension work in connection with cotton ginning. Six states—Georgia, Louisiana, Mississippi, Oklahoma, South Carolina, and Texas—now have either full-time or part-time cotton-ginning specialists.

* * * *

Evaporation data developed by A. A. Young in a study at the La Verne covered reservoir in southern California, indicated that evaporation from a floating Weather Bureau pan protected from direct sunlight and wind by the reservoir roof was 29 inches less, between June 1, 1935 and May 1, 1936, than the evaporation from a similar type of exposed land pan. If the generally accepted coefficient of 0.70 is applied to the land pan, and it is assumed that the floating pan represents reservoir evaporation, the saving in water due to covering the reservoir would be about 13.7 inches in eleven months, which is a small saving compared with the cost of roofing the reservoir. The least evaporation from the reservoir occurred during the summer when the loss from the land pan was at its maximum. During the winter evaporation from the floating pan was slightly greater than from the land pan.

* * * *

R. B. Gray left New York July 22 on a two months' trip through Europe to study the latest developments in farm machinery research. He plans to visit England, France, Germany, Sweden, Denmark, Belgium, and Italy, and will contact the leading agricultural engineers and research institutions in those countries.

* * * *

The 1936 small grain harvest in the corn belt was of short duration due to extreme hot dry weather. Work on the testing of small combines in Illinois has been completed, and W. M. Hurst has returned to the Washington office. W. R. Humphries reports from Indiana and George Stafford from Ohio that field work in these states will also be finished in the near future. This season has been very favorable for the use of the combine and large numbers of the small power take-off machine have been used. Results of field tests and observations during 1935 and 1936 show satisfactory performance in harvesting both small grain and soybeans.

* * * *

Bulletins issued during the past month are:

Care and Maintenance of Cotton Gin Saws and Ribs (Circular 393)

Effect of Artificially Drying Seed Cotton before Ginning on Certain Quality Elements of the Lint and Seed and on the Operation of the Gin Stand (Technical Bulletin 508).

Contributions Invited

All public-service agencies (federal and state), dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

From Georgia

THE agricultural engineering department at the University of Georgia reports research and other activities as follows:

Under an agreement becoming effective February 1, 1936, a cooperative research program was initiated between the USDA Bureau of Agricultural Engineering, division of farm structures, and the University of Georgia, department of agricultural engineering. The general purpose of the work under this agreement is to develop more satisfactory types of low-cost construction for farm houses, for livestock, and for storage structures.

The immediate objectives are to determine temperature, *(Continued on page 398)*

Farm Development Investigations (BAE, USDA)

THE farm development unit of the Bureau of Agricultural Engineering, U. S. Department of Agriculture, is organized under the direction of George R. Boyd, assistant chief of the Bureau, for the purpose of carrying on research work in land clearing, farm studies in farm operating efficiency, and service work in engineering appraisals.

Probably the most outstanding work in land clearing was the reworking and distribution of over 120,000,000 pounds of surplus war explosives to farmers and road builders. This work was completed in 1928 and at present there are no active projects in land clearing.

The farm operating efficiency project is a study of the application of agricultural engineering science to individual farms. It seeks to discover the agricultural engineering needs of typical farms and to determine the benefits which will accrue to the farmer when the indicated improvements are made. It grew out of a recognition of the fact that no general recommendations as to the adoption of specific engineering improvements could be made; that is, that all farmers could not be encouraged to buy tractors, to drain their lands, or install irrigation systems. It is evident that the practices and equipment necessary for the efficient operation of any farm are determined by the circumstances and conditions surrounding the individual farm. It became evident that engineering efficiency depended upon an efficient farming program, in which each element of the farm business was in proportion to other elements, and to the farm business as a whole. The project is now developed to the point where typical farms in eight states have been surveyed in cooperation with state agricultural experiment stations, agricultural engineering departments, and farm management specialists. N. A. Kessler and G. R. Shier are in direct charge of this project.

The engineering appraisal work of the unit is carried on through the department committee on the valuation of lands in the flood control area, of which George R. Boyd is chairman. O. M. Page has been in direct charge of the field operations of the appraisal unit, which since 1930 has appraised 4,230,000 acres of land for the War Department in connection with flood control improvements on the Mississippi River. One of the outstanding activities of the unit was the appraisal of lands in the Sardis Reservoir area on the Tallahatchie River in Mississippi. A parcel appraisal of this area, containing about 690 tracts and embracing about 100,000 acres, was made in three months. Options were taken by the War Department on the basis of these appraisals at a saving of approximately $1,000,000 as compared to prior options taken before appraisals were made. About 95 per cent of the entire acreage is now under option and construction work has been started. The unit has made extensive flood control surveys and backwater damage reports, and has covered by reconnaissance or in detail more than 8,000,000 acres of lands on the Mississippi River and tributaries in connection with the flood control activities of the War Department.

NEWS

North Atlantic Section Announces Tentative Program

A THREE-DAY program at Skytop Lodge, Skytop, Pennsylvania, October 15, 16, and 17, has been announced for the yearly meeting of the North Atlantic Section, American Society of Agricultural Engineers.

Following registration of members and visitors on Thursday morning, October 15, the program will open with a general session at 2:00 o'clock p.m., with W. T. Ackerman, head of the agricultural engineering department at the University of New Hampshire, presiding.

George A. Rietz, in charge of the rural electrification section of General Electric Company, will address the session as chairman of the North Atlantic Section. R. U. Blasingame, professor of agricultural engineering at Pennsylvania State College, and president of the American Society of Agricultural Engineers, will present a paper on "Mechanization of Agriculture."

M. L. Cooke, administrator of the Rural Electrification Administration, has been asked to address the session on "The Federal Program of Rural Electrification."

Round table discussions on farm machinery, farm structures, conservation, and rural electrification have been scheduled for the first evening. Members named to preside over the sessions in the order named are Harold Pinches, assistant professor of agricultural engineering, Connecticut State College; A. M. Goodman, extension professor of agricultural engineering, Cornell University; S. P. Lyle, senior agricultural engineer, USDA Bureau of Agricultural Engineering; and A. V. Krewatch, specialist in agricultural engineering extension, University of Maryland.

Friday morning will be given to a second general session at which Mr. Rietz will preside. H. H. Bennett, chief of the USDA Soil Conservation Service, has been asked to talk on "Safeguarding Our Soil Resources," and P. H. Powers, to develop the subject of "Electrifying American Agriculture." L. F. Livingston, immediate past president of the Society and manager of the agricultural extension section of E. I. du Pont de Nemours and Company, will discuss "Engineering Frontiers in Agriculture."

This session will close with a business meeting of the Section.

Simultaneous sessions devoted to the major technical interests of the members are scheduled for Friday afternoon. Mr. Livingston is to preside at the conservation session; C. I. Gunness, professor of agricultural engineering at Massachusetts State College, the structures session; C. W. Kelsey, president of Rototiller, Inc., the machinery session; and D. E. Blandy, rural service division of New York Power and Light Corp., the electrification session.

One of the Section members, Harper Sibley, part owner and manager of Sibley Farms, and president of the United States Chamber of Commerce, is slated to address the annual banquet of the Section on Friday evening.

Saturday morning the technical interests will hold simultaneous final sessions, featuring short presentations and ample time for discussion. In the chair for the structures session will be Wallace Ashby, chief of the division of structures, USDA Bureau of Agricultural Engineering; for the machinery session, J. R. Haswell, professor of agricultural engineering extension, Pennsylvania State College; for the electric session, F. L. Rimbach, director of rural development for the New England Rural Electrification Committee; and for the conservation session, F. D. Cornell, Jr., assistant professor of farm mechanics at West Virginia University.

Opportunity for the members and visitors to enjoy some recreation together will be provided on Saturday afternoon. Non-members of the Society, as well as members from parts of the country outside of the North Atlantic Section, are invited to attend.

Washington News-Letter

from AMERICAN ENGINEERING COUNCIL

THE reorganization movement referred to in the June letter is gaining momentum with three investigating committees holding the "axe over Washington." Each committee is moving cautiously, and while the President's Committee on Administrative Management is most active among government officials, no hearings are reported to be scheduled prior to November elections. In the meantime, there is much speculation regarding the seriousness of the reorganization intentions and the possibility that overlapping responsibilities may result in frustration of purpose.

Although similar studies in the past have each left their train of broken promises, false hopes for retrenchment, futile congressional investigations and ineffectual recommendations, the field never seemed so ripe for reorganization and economy measures. Entering many new activities, the federal government has piled 40 new agencies on top of an already top-heavy administrative structure. Civil service reports an increase of more than 250,000 civilian employees since February 1933. Unofficial figures show the federal payroll for June 1936 was $326,159,486.00 for 4,664,732 employees. That is an obligation of about $2.65 per month against every man, woman, and child in the United States.

On the receiving end, it is estimated that 16,314,248 people have already received benefits from the emergency agencies. Emergency funds have gone into every state and territory, and congressional appropriations for that purpose run into many billions.

The proportions of the task ahead of the reorganization committees are difficult to visualize, but an idea may be gotten from reports that duplications in service and overlapping functions between old and new bureaus have reached a point where there are as many as 23 agencies dealing seriously with a single problem. Such knowledge is said to have been in possession of Senator Byrd when he succeeded in getting the Senate resolution authorizing the investigation to read that the Senate investigating committee should sit, not only in the next, but in "succeeding Congresses."

Regardless of past experience and political implication, the Byrd resolution, with a continuing authority to bring administrative inefficiencies to the surface, stands without handicap except for limitation of funds, until repealed by an act of Congress.

Public works inventory for 1936 is a joint undertaking by PWA and WPA under direction of the National Resources Committee. It will be similar to the one made a year ago but it is to include all public works possibilities for the next six years. The field work is to be done by local government employees of the cooperating agencies, who are to submit their estimates to the planning boards of 46 states. Project possibilities are to be classified by type, geographical location, and priority. Such inventories have not been important factors in the approval or rejection of individual projects but their continuation suggests that the administration is not abandoning "made work" for the jobless.

The engineering profession is honored by having one of its best known members chosen as chairman of the Third World Power Conference meetings. Dr. William Durand, professor emeritus of mechanical engineering at Leland Stanford University, Palo Alto, California, will serve in that capacity. Since he is also a linguist, he will make his address of welcome in English, French, German and Spanish.

Sponsored and financed jointly by the United States Government and the electrical industry of the United States, the Third World Power Conference is expected to engage the attention of engineers, scientists and economists of the world in a study of national power economy. The American Committee is endeavoring to make it an international forum where all sides of questions growing up around public and private power policies can be presented to the entire world on a basis of free and frank discussion without personalities, politics, or propaganda.

The Bureau of Labor Statistics of the Department of Labor has made a limited number of reprints of the first release of findings in the "Survey of Engineers" available for distribution. American Engineering Council's Committee on the Survey of Engineers and Engineering will be glad to have your comments addressed to the AEC headquarters at 744 Jackson Place N.W., Washington, D. C.

At the request of the Lewis Historical Publishing Company of New York, publishers of the three earlier editions of "Who's Who in Engineering," a sponsoring committee for the fourth edition has been appointed by President Andrey A. Potter. Because of his previous service on similar committees, President Potter has been prevailed upon to act as chairman.

It is anticipated that the questionnaires outlining the qualifications for inclusion in the new edition will be mailed to members of the profession early in the fall. Engineers eligible for this new edition will be listed without obligation. The new edition will be published in the spring of 1937 and may be purchased for $10.00 per copy.

What Agricultural Engineers Are Doing

(Continued from page 396)

humidity, air motion, and lighting conditions in typical farmhouses and farm buildings; to evaluate the absorption of solar radiation and atmospheric heat by farm buildings; to devise inexpensive structural means, including the utilization of agricultural by-products, for maintaining satisfactory temperature, humidity, and air motion conditions in farmhouses and farm buildings; and to test the economic value of these findings in the growth, mortality, and production of animals in animal shelters, and on the preservation and storage of food and feed stuffs in storage buildings.

Several farmhouses representing typical rural southern conditions were selected for the initial study. Early in the investigation thermocouples and hot-wire anemometers were installed so that temperature and air motion studies might be facilitated within these houses. A portable stand on which thermocouples are mounted is used to secure isothermal cross sections of the several rooms under study. To further promote the study of air currents, a portable hot-wire anemometer has also been devised. Both air motion and temperatures are calculated by measuring the potential drop, using a potentiometer.

A further provision in the research outline calls for the building of an experimental house. The structure just being completed may be readily altered to facilitate observation of the influence of designs and materials upon temperature and air movement in the building.

* * * *

The agricultural engineering department holds a unique position in the building expansion program of the university system of Georgia. The departmental staff has prepared plans and specifications for and is supervising the construction of five buildings at the University proper. Plans for seven more buildings are being rapidly prepared and bids will be entertained at an early date.

In addition to the expansion program at the University, other state schools are not being neglected. Twelve buildings consisting of dormitories, dining halls, library and similar college structures are under way. Nine of these have been designed and construction supervised by the agricultural engineering department.

Plans for paving the roads on the University campus have also called the department into action. Under the direction of the staff members, student surveyors have carefully surveyed and mapped the complete road system.

* * * *

The department, in conjunction with the extension service, has attempted to extend its activities directly to the farmers of the state. "Livestock Legume Day," short courses, "Farmers' Week," and shop contests for vocational agricultural students have been instrumental in stimulating a helpful interest and a cooperative spirit between the department and the farmers of Georgia.

* * * *

A crimson clover harvester has recently been designed which has proven successful in preliminary trials. Studies have been initiated which involve soil and water conservation, and a survey of the most suitable farm building materials in the state.

* * * *

New staff members include J. W. Simons, junior agricultural engineer, U. S. Department of Agriculture, and Frank B. Lanham, research engineer. Mr. Simons is connected with the farm housing investigation, and Mr. Lanham is interested in both the research and teaching fields.

* * * *

Anticipating the opening of the regular session in September, a new one-story farm shop building, housing farm carpentry, blacksmithing, and machine tool laboratories, has been constructed. Barrow Hall, the agricultural engineering building, has undergone some needed repairs. Remodeling and rewiring have been in progress during the summer months, making ready for an expected class of one hundred and ten agricultural engineering students at the opening of the school year.

From New Jersey

TWO subprojects under agricultural engineering project No. 1, "Farm Buildings and Appurtenances," have been under way for nearly a year at the New Jersey Agricultural Experiment Station.

The first problem is to select a suitable protective material for covering the commercial insulating boards commonly used in poultry houses. Various color paints and finishes are being used in an effort to find or develop a covering which the birds will not pick and which is otherwise durable.

The second problem includes investigations to determine the value of insulation in the New Jersey type open-front poultry house and the most suitable housing conditions for poultry in New Jersey. These studies are being conducted in insulated and uninsulated houses of the New Jersey type and in similar insulated, uninsulated, and insulated and heated pens in a multiple-unit house at the college poultry plant. During cold weather the air movement in these pens is regulated by closing all windows and forcing an equal quantity of air through each of the pens. The temperature in the heated pen is kept from going below a predetermined point by a thermostatically controlled electric heater fitted into the air supply pipe.

ASAE Meetings Calendar

October 15 to 17, 1936—North Atlantic Section—Skytop Lodge, Skytop, Pa.

October 23 and 24 (or 30 and 31), 1936 (tentative)—Pacific Coast Section, at Moscow, Ida., and Pullman, Wash.

November 30 and December 1 to 3—Power and Machinery Division, Rural Electric Division, Farm Structures Division, and Soil and Water Conservation Division (individual and joint programs)—Stevens Hotel, Chicago.

February 3 to 5, 1937—Southern Section (in conjunction with annual convention of the Association of Southern Agricultural Workers)—Nashville, Tenn.

June 21 to 24, 1937 (tentative dates)—Annual meeting of the Society—University of Illinois, Urbana-Champaign.

Personals of ASAE Members

M. G. Huber has been appointed extension specialist in agricultural engineering at the University of Maine, Orono. He was formerly instructor in agricultural engineering at Pennsylvania State College.

D. B. Lancaster, a recent graduate in agricultural engineering from the A. & M. College of Texas, has been appointed to the rural service staff of the Texas Power and Light Company, and is located at Taylor, Texas.

Lee C. Prickett has been appointed rural electrification specialist, extension service, University of Georgia. His new address is 45 N. Thornton Ave., Dalton, Georgia. He was formerly assistant director of the Committee on the Relation of Electricity to Agriculture, and more recently assistant rural engineer, industries division, Tennessee Valley Authority.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the August issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Frank M. Caperton, agricultural engineer, Delta Experiment Station, Stoneville, Miss.

Bernard T. Colley, chief metallurgical engineer, general superintendent, manager of farms, Cerro de Pasco Copper Corporation, La Oroya, Peru.

Hal F. Eier, extension engineer, Kansas State College, Manhattan, Kans. (Mail) 1001 Osage St.

Joseph A. Faucher, sales engineer, tire engineering and service division, U. S. Rubber Company, 6600 E. Jefferson St., Detroit, Mich.

Basil Issigonis, agricultural engineer, Bethel House, King St., Oakville, Ont., Canada.

Robert L. James, lecturer in agricultural engineering, Canterbury Agricultural College, Lincoln, New Zealand.

Lee Lloyd, manager, ultraviolet section, The Miller Company, Meriden, Conn. (Mail) 239 Bradley Ave.

Vladimir A. Von Reimers, electrical department, Bethlehem Shipbuilding Corporation, San Francisco, Calif. (Mail) 1338 Masonic Ave.

TRANSFER OF GRADE

H. O. Hill, senior soil conservationist, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 4301 W. 26th St., Bryan, Tex. (From Junior Member)

This carriage salesman laughed at horseless buggies

Later he wished he hadn't

SOME THINGS are so outstandingly better that they are bound to succeed. The high compression automobile was one of them. The high compression tractor is another.

Success in any business goes to the men—and to the companies—who get on the winning side early. Today it is not yet too late to get on the winning side in the tractor business.

Old-fashioned low compression tractors had one low-cost leg to stand on: they would "burn anything." Now that has been changed for nearly all sections of the country by the fuel economy tests of Agricultural Colleges and the experience of thousands of farmers who find that good gasoline and high compression engines save them money.

High compression tractors designed for 70 octane regular gasoline have these advantages: (1) greater power (2) less fuel per acre (3) increased torque (4) starting and running on the same fuel (5) full performance in cold weather (6) lower maintenance cost (7) longer engine life (8) instant response to governor (9) ability to idle (10) savings in oil bills by the elimination of wasteful crankcase dilution (11) less waste heat to cooling water . . . *plus* the convenience of using one good fuel —the uniform, dependable, regular gasoline of 70 octane quality—sold by leading oil companies everywhere.

Today anyone who wonders how to build for success in the tractor business should check these facts thoroughly. It is not too late to get on the winning side—the high compression side. Ethyl Gasoline Corporation, Chrysler Building, New York City, manufacturers of anti-knock fluids for premium and regular gasolines.

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If you want to sell more tractors—

DESIGN FOR 70 OCTANE GASOLINE

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

A DEVICE FOR MEASURING PRECIPITATION WATERS LOST FROM THE SOIL AS SURFACE RUNOFF, PERCOLATION, EVAPORATION, AND TRANSPIRATION, *G. W. Musgrave.* Soil Sci., 40 (1935), No. 5, pp. 391-401, pls. 3, fig. 1. After a brief analysis of the shortcomings of lysimeter systems previously described, a set-up devised at stations of the USDA Bureau of Chemistry and Soils is presented, with working drawings and photographs of various stages in the construction and manipulation; and the manner in which the failings of earlier designs are overcome is shown.

Cylinders 3 feet in diameter and 3 feet deep are gradually forced into the soil in such a manner as to preserve not only the soil structure but also the original vegetation and the original slope. The filled cylinders are placed upon drainage-collecting bases of cement in which the soil column rests upon a layer of fine gravel which, in turn, lies upon a layer of coarse gravel, both gravel layers having previously been washed with hydrochloric acid and then with distilled water. Surface outlets take care of surface runoff, and the supplementary rain gages are placed with their tops at a height the same as that of the soil cylinders.

STATUS OF TOWN AND VILLAGE HOUSING IN IOWA, *M. G. Reid.* Iowa Sta. Res. Bul. 186 (1935), pp. 49-173, figs. 41. In this bulletin are presented the results of a survey made of housing conditions in Iowa towns and villages having a population of less than 2,500. Information was obtained concerning 8,798 houses, 5,081 owner and 3,506 tenant homes in 10 typical agricultural counties and 211 homes in towns where mining is important.

The villages and towns studied are largely service and residence centers for farm communities. The proportion of people in business for themselves is relatively high while that of wage earners is low. Many of the heads of families are retired farmers or women without gainful occupation, and during the past decade, except in the case of larger towns, the population has been declining slightly.

Iowa village and town families own their homes more frequently than do those on farms or in cities. In 1930 the median value of owned homes was $2,739 and the median rent of tenant homes was $14.89 a month. Most of the families live in one-family dwellings no part of which is used for an office or commercial purposes, while about 5 per cent live in dwellings connected with businesses or in dwellings for two or more families.

The houses are largely painted frame structures, only 7 per cent being stucco, brick, stone, or concrete. One in 4 is one-story and 1 in 5 was built 50 or more years ago. Except in industrial towns very few houses have been built in the past 10 years.

The houses average 6.4 rooms, but only 3 in 4 have a dining room and 2 in 5 a bathroom. Most houses needed some repair, and on only 28 per cent was the paint reported as being in good condition. Approximately 6 per cent of the houses needed replacement. Piped water was reported in only 2 in every 5 families and less than 1 in 3 had piped hot water. Sixty per cent of the families carried water an average distance of 82 feet. Three in every 4 families either had a kitchen sink with drain or expressed a desire for one. Many of the towns have no sewage disposal system, and nearly 45 per cent of the families disposed of all sewage on the surface.

About 88 per cent of the families reported electric power line connections and 40 per cent reported either ice or mechanical refrigeration. Gas or electric stoves for cooking were reported by only 13 per cent, while kerosene or gasoline stoves were reported by 71 per cent of the families. Nearly 2 in every 3 families had power washing machines. Most families had a garden including fruits and vegetables. Nearly two-thirds of the families had good lawns, but only 48 per cent had good shade trees. Shrubs, flowers, and vines were relatively poor.

Tenant homes, including both houses and yards, were shabbier than those of owners and were not so well equipped with modern conveniences. The condition of the houses was not influenced by the size of town, but the better equipment was found in the homes of the larger towns.

On the average, professional families had better houses than any other occupational group. The larger the family the poorer the dwelling and the fewer the facilities. The older the houses the poorer their condition. In recent years brick has been used more commonly than in former years. Houses built during the past 10 years have fewer rooms and the proportion of modern facilities has increased. Laborers' houses, on the other hand, are relatively poorer in facilities than those built from 10 to 25 years ago.

Towns with an increasing population have houses in better condition than towns with decreasing population. Nonindustrial towns have better houses than industrial towns. The condition of town and village houses was much the same as that of farmhouses in the same counties.

THE USE OF CLEANERS IN THE DAIRY PLANT, *H. J. Barnum, P. S. Lucas,* and *B. Hartsuch.* Michigan Sta. Spec. Bul. 262 (1935), pp. 24, figs. 2. These studies were undertaken to determine the properties and efficiency for specific purposes of various dairy cleaners. The cleaners studied were divided into the following classes—modified or neutral sodas, soda ash, special alkalies, trisodium phosphate, and colloidal. Aside from the trisodium phosphate, the cleaners were similar in composition.

While all of the cleaners were sufficiently soluble as ordinarily used, soda ash was the most soluble, followed by modified sodas, special alkalies, trisodium phosphate, and colloidal. Some of the cleaners were highly buffered and resistant to reduction in cleansing ability. In most cases tap water retarded this action more than distilled water. The modified sodas were most stable in buffer action, followed by soda ash and colloidal, special alkalies, and trisodium phosphate. In causticity the special alkalies were highest, trisodium phosphate second, soda ash and colloidal about equal, and modified sodas lowest. For removing butterfat from a utensil by emulsification the special alkalies were most efficient, but could not be used for hand-washing because of their caustic action. Soda ash and colloidal were second in efficiency in this respect, followed by modified sodas and trisodium phosphate. Soda ash was the most efficient water softener, followed in order by colloidal, modified sodas, special alkalies, and trisodium phosphate.

Cleaners containing abrasives are commonly called "detergents." Aluminum and copper were very severely scratched by the volcanic ash content of such cleaners, while tinned copper and tinned steel were severely scratched, nickel moderately scratched, and Ascoloy and chrome nickel steel were unaffected. Special alkalies were very severe in their corrosive action on metals, trisodium phosphate was second in severity, soda ash third, and colloidal and modified sodas were least destructive. Tinned steel was most subject to corrosion, aluminum second, followed by tinned copper and copper. Nickel was but slightly affected by corrosion, and Ascoloy and chrome nickel steel appeared to be entirely resistant. While many of the cleaners had distinct disadvantages for use on metals, these objections may not hold for glassware washing.

GRASS SILAGE, *J. P. Drew, G. F. O'Sullivan,* and *D. Deasy.* [Irish Free State] Dept. Agr. Jour., 33 (1935), No. 1, pp. 1-22, pls. 2. In studies at University College it was found that grass silage of excellent quality could be produced in an inexpensive concrete silo from unchaffed material. Grass containing a high proportion of stemmy material was not as suitable as that of a more leafy type, especially when silage was made by the acid method, owing to the difficulty of close packing. Under existing conditions small wooden silos were not suitable for silage production, even by acid methods.

The production of silage by acid treatments required a great deal more labor and delay than was incurred in the making of natural fermentation silage. The addition of acids or of acids and sugar to grass resulted in a reduction in the loss of dry matter. The acidification of green material produced a medium suitable for mold development during the period of storage and emptying of the silo, and molds often developed to such an extent as to offset the saving in dry matter effected by the addition of acid. While the addition of acids or acids and sugars did not entirely prevent protein degradation, it materially reduced the extent to which it took place. For dairy cows grass silage produced by acid methods was about equal in feeding value to that produced by natural fermentation. The natural fermentation method is considered to be the most convenient, reliable, and economical for general adoption when grass can be cut at a stage of growth where it is possible to handle it by ordinary farm machinery. *(Continued on page 402)*

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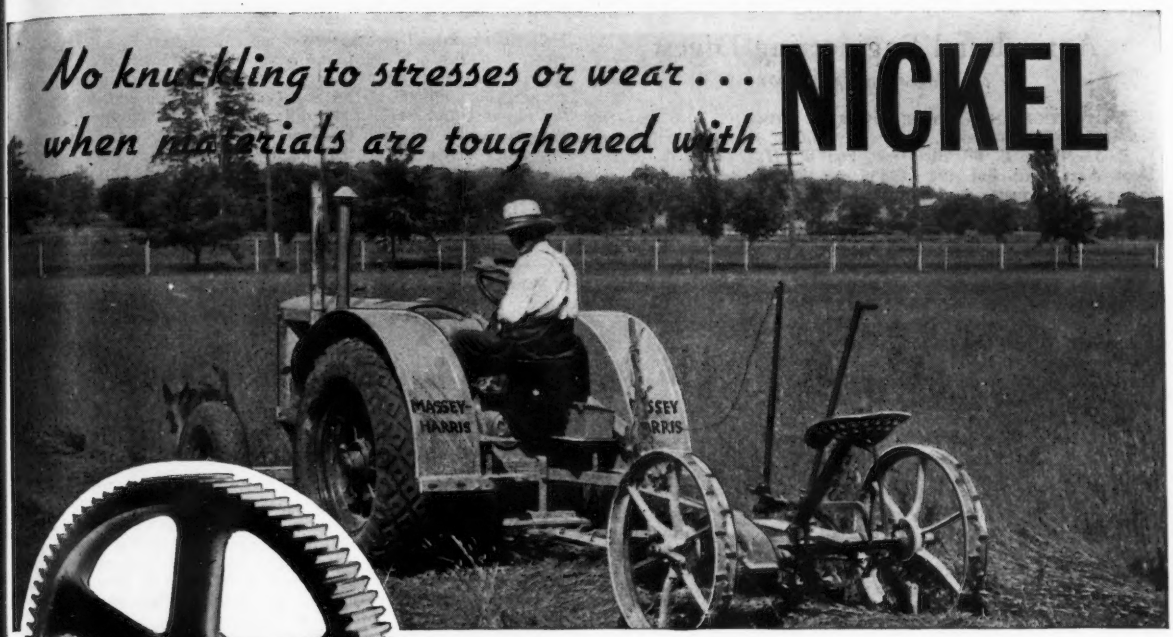

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Agricultural Engineering Digest

(Continued from page 400)

UTILIZATION AND COST OF POWER ON MISSISSIPPI AND ARKANSAS DELTA PLANTATIONS, *L. A. Reynoldson, W. R. Humphries, S. R. Speelman, E. W. McComas,* and *W. H. Youngman.* U. S. Dept. Agr., Tech. Bul. 497 (1935), pp. 47, figs. 10. This investigation was conducted cooperatively by the USDA Bureaus of Agricultural Economics, Agricultural Engineering, and Animal Industry and the Mississippi and Arkansas Experiment Stations. It related to the use and cost of power on 161 plantations in the Delta sections of Mississippi and Arkansas.

Of the 161 plantations surveyed, 65 were operated with general-purpose tractors and mules, 63 with mules alone, 19 with tractors of mixed types and mules, and 14 with ordinary tractors and mules. Mixed tractor plantations averaging 1,806 acres were the largest and mule plantations with 941 acres were the smallest. For all plantations cropland averaged 74 per cent of the total area and cotton occupied 75 per cent of the cropped land.

On all general-purpose tractor plantations there was an average of 1,094 hours of tractor work per year, on mixed-tractor plantations 1,853 hours, and on ordinary-tractor plantations 470 hours. Mules on mule plantations did an average of 112 10-hour days work per year, on both ordinary and mixed-tractor plantations 108 days, and on general-purpose tractor plantations 100 days. Mule hauling, including time for loading, unloading, and waiting, as at the cotton gin, required 2.3 hours per mile. Motor-truck hauling required only 11 minutes per mile. Man labor varied from 117.5 hours per acre in cotton with general-purpose tractors to 190 hours with mules. On 24 plantations, the drawbar requirements per acre of cotton produced principally with tractor power amounted to 6 tractor-hours and 4.1 mule-hours.

The average annual cost of using tractors, exclusive of the operator's labor, was 70 cents per hour, based on an average of 705 hours of operation. Power by general-purpose tractors cost 66 cents per hour based on 733 hours; by mixed-type tractors, 71 cents based on 733 hours; and by ordinary tractors, $1.04 based on 439 hours of use annually. Fuel and lubricants constituted 41 per cent, and depreciation constituted 36 per cent, of the total tractor operating cost. Repairs fluctuated with the age of the machines and ranged from 6 cents per hour for general-purpose tractors to 19 cents for ordinary tractors. The average age of ordinary 2-plow tractors was 4.8 years, 3-plow tractors 3.5 years, and general-purpose tractors 1.8 years. The annual cost of using tractor-drawn implements ranged from $22 for middle busters to $64 for 4-row cultivators. The cost per hour of mule work was lowest, 12.5 cents, on mule plantations where mules worked 112 days, and it was the highest, 14.6 cents, on general-purpose tractor plantations where they worked 100 days.

The average yearly cost of motor-truck operation was 69 cents per hour for trucks with trailers and 53 cents for those without trailers. The average cost of power for all tractor plantations was $11.48 for each acre in cotton. Investment in power machinery for all tractor plantations averaged $4.24 per acre in cotton. The average cost of power on mule plantations amounted to $10.63 per acre in cotton. The cost of drawbar work on crops with mules and tractors ranged from $8.54 per acre in cotton on general-purpose tractor plantations to $10.40 on mixed-tractor plantations. On mule plantations, the cost was $8.64 per acre in cotton. Such costs per crop acre ranged from $6.47 on general-purpose tractor plantations to $7.29 on mixed-tractor plantations, and were $6.66 on mule plantations.

TREES AND EROSION CONTROL, *A. C. McIntyre.* Amer. Soil Survey Assoc. Rpt., 15 (1934), pp. 110-114. This article, a joint contribution from the Soil Erosion Service, U. S. Department of the Interior, and the Pennsylvania Experiment Station, presents preliminary data on the growth rate of different species, the effectiveness of the crowns in protecting soil from beating rains, the amount and value of tree litter and humus, and the extent and effectiveness of the root systems of different species.

THE CLAY RATIO AS A CRITERION OF SUSCEPTIBILITY OF SOILS TO EROSION, *G. J. Bouyoucos.* Jour. Amer. Soc. Agron., 27 (1935), No. 9, pp. 738-741. From an analysis of existing data the author of this contribution from the Michigan Experiment Station reaches the conclusion that the (sand+silt)/clay ratio in soils may prove to be a criterion of value in judging the relative susceptibility of soils to erosion. This ratio is designated "the clay ratio." It was compared with the erosion ratio "by using the same soils and the same mechanical analyses of these soils as reported by the USDA Bureau of Chemistry and Soils. The comparison shows that with few exceptions the two ratios agree fairly well in indicating the general susceptibility of soils to erosion."

SOIL EROSION INVESTIGATIONS AT THE SOUTH CAROLINA STATION, *T. C. Peele.* South Carolina Sta. Rpt. 1935, pp. 25-28, figs. 2. A progress report is presented of investigations being conducted in cooperation with the USDA Soil Conservation Service. Studies of the physical properties of the different soil types of the Piedmont Plateau Region of South Carolina, with particular reference to the properties which indicate their erosive characteristics, show that the soil loss is largest when land is bare of any cover. Cotton showed the largest soil loss of any of the crops, with corn second, lespedeza next, and Bermuda grass least. More than 15 times as much soil was lost from the cotton as from the lespedeza plat, and over 136 times as much soil was lost from the cotton as from the Bermuda grass plats.

These data emphasize the necessity of using close-growing crops such as lespedeza and Bermuda grass on areas subject to excessive erosion. Steep slopes should be used for hay production, pasture, or be put back in woods. Clean cultivated crops, such as cotton and corn, cannot be grown on steep slopes over a period of years without ultimately ruining the soil for agricultural purposes.

Studies also are in progress on the effect of a soil mulch on erosion and on concentration of soil in runoff water from terraced areas. The latter indicate that terraces planted in lespedeza showed from 55 to 90 per cent less soil in suspension in the runoff water than the terraces planted in cotton.

COMPARATIVE COST OF OPERATION OF A FORDSON TRACTOR USING KEROSENE AND ALCOHOL AS MOTOR FUELS, *A. B. Catambay* and *N. L. Cuevas.* Philippine Agr., 24 (1935), No. 7, pp. 549-561, fig. 1. Studies are reported on engine performance, cost of field operations, and oil and fuel consumption of a tractor using kerosene and alcohol fuels. The field operations consisted of plowing with a 2-furrow, 24-inch disk plow.

It required 1.15 times as much alcohol as kerosene by volume to plow the same area, and there was a saving of 0.63 hour per hectare (2.471 acres) when using kerosene for fuel as compared with alcohol. The cost of field operation was cheaper with alcohol than with kerosene.

It was found that to operate the tractor with alcohol at the same fuel cost as with kerosene, the price of alcohol should be 0.87 times the price of kerosene. The present price of alcohol is 0.66 times the price of kerosene. The tractor cannot be started with kerosene but can with alcohol. The engine starts more readily on alcohol in hot weather than in cold. At the heavier loads alcohol fuel gave a better performance than kerosene fuel.

EFFECT OF GRINDING ON DIGESTIBILITY OF ARGENTINE FLINT CORN, *J. C. Fritz.* Poultry Sci., 14 (1935), No. 5, 267-272. The digestibility of whole, cracked, and finely ground Argentine flint corn was studied by the USDA Bureau of Animal Industry, using Rhode Island Red cocks which were surgically altered so that the urine and feces were voided separately. Coefficients of apparent digestibility were determined for total dry matter, organic matter, crude and true protein, ash, ether extract, crude fiber, and nitrogen-free extract.

Grinding did not change the apparent digestibility except in the cases of organic matter, ash, and ether extract. The difference in digestibility of the organic matter was caused by the ether extract portion, and without the ether extract the digestibility of the organic matter was not significantly influenced. Coarse cracking increased the digestibility of ether extract to near its maximum digestibility, while fine grinding was required to improve the utilization of ash. In general, grinding Argentine corn resulted in a slight but probably not significant increase in digestibility. This corn had essentially the same digestibility as dent corn.

BIBLIOGRAPHY ON STONE HOUSES, 1920-1934, compiled by *D. W. Graf.* U. S. Dept. Agr., Bur. Agr. Engin., 1935, pp. [5]. A partial list of references.

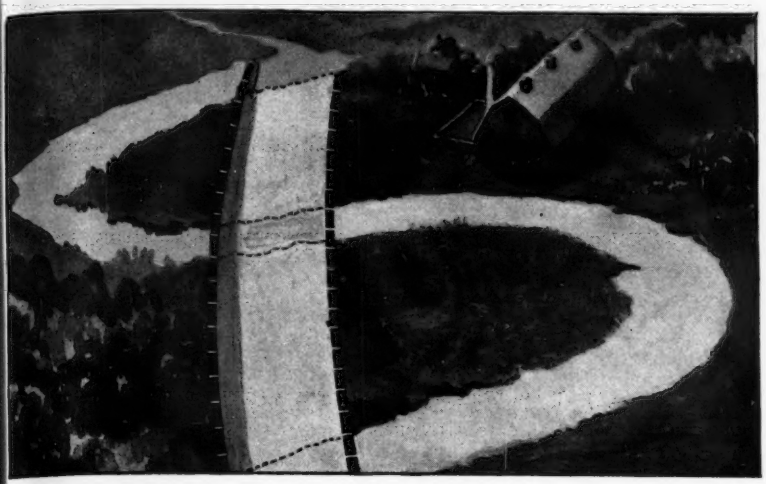
BIBLIOGRAPHY ON FIREPLACES, 1900-1934, compiled by *D. W. Graf.* U. S. Dept. Agr., Bur. Agr. Engin., 1935, pp. [17]. A selected list of references.

A FORMULA FOR CAPACITIES OF RESERVOIRS, *G. C. Dobson.* Soil Conserv. [U.S.], 1 (1936), No. 7, pp. 7-9, figs. 3. A formula is described which was developed specifically for computing original and present capacities and silt volumes in storage reservoirs.

THE FEASIBILITY OF USING A HEAT STORAGE DEVICE FOR DOMESTIC HEATING WITH ELECTRICITY, *H. J. Dana* and *R. E. Lyle.* Wash. Engin. Expt. Sta. Bul. 46 (1935), pp. 20, figs. 5. Experiments on the use of a heat storage device are reported. The device used involved a heat storage oven filled with granite boulders.

While the results reported are only preliminary, they indicate that so far as the occupants are concerned there was no apparent difference between this type of heating and heating by the hot air furnace.

(Continued on page 404)



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ATLAS

EXPLOSIVES

CHEMICALS ATLAS EXPLOSIVES

Agricultural Engineering Digest

(Continued from page 402)

ELECTRIC BROODERS ON INDIANA FARMS, *T. E. Hienton.* Indiana Sta. Circ. 187, 2. rev. (1936), pp. 4, figs. 2. Records of electric energy consumption of 66 brooders are reported and discussed.

Electric energy consumption per chick raised varied from less than 0.25 to more than 1 kilowatt-hour, due to differences in mortality, numbers of chicks brooded, and other factors. Utilizing a brooder to its capacity reduces the consumption per chick raised.

Data on chick mortality in electric brooders also are included.

SOIL BLOWING AND ITS CONTROL IN COLORADO, *J. F. Brandon* and *A. Kezer.* Colorado Sta. Bul. 419 (1936), pp. 20, figs. 12. It is pointed out in this bulletin that soil-blowing control is incident to and bound up with the breaking up of the ground-line sweep of the hard, driving winds of the winter-spring period. The best soil-blowing protection is a well-anchored, dense cover of dead or dormant vegetative matter. Necessary summer cultivations should not unduly fine the surface soil. A flocculent condition of the surface soil is difficult to recreate, once it has been destroyed by grinding, pulverizing implements. Cultivation to control soil-blowing spots should not only create furrows but should go deep enough into the hard, tight subsoil to lift clods to the surface. Cultivation which only moves loose blow soil is not effective as erosion control. Furrows intended to break up a blow spot must be not only deep enough to lift clods to the surface but must be close enough together that the soil blown from between will not ride over. The fountainhead of any soil-blowing stream can be broken up by roughening the surface by means of furrowing implements that penetrate deeply enough to lift flocculent, cloddy soil to the surface. These may eventually be eroded down into blow soil and the furrows leveled, in which case the middles must be broken, raising another lot of clods to the surface.

A blow condition never corrects itself nor stays confined to one spot. The sweep of soil particles tends to weather down and to set in motion any and all soils in its path, no matter how blow-free they may be within themselves. Blow spots must be worked. Nothing is more essential in a blow-control program for any region.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE MISSOURI STATION, *J. C. Wooley* et al. Missouri Sta. Bul. 358 (1935), pp. 32-36, figs. 2. The progress results are briefly presented of investigations on the effect of tillage methods on costs and yields of corn, corn planter fertilizer attachments, capacity of silos, loafing barn for milk cows, and the grade in a fill above a soil-saving structure.

SMALL SAWMILL IMPROVEMENT, *C. J. Telford.* U. S. Dept. Agr., Forest Serv., Forest Prod. Lab., 1935, pp. 3, pl. 1. Practical information is presented in mimeograph form.

EFFECT OF EXTRACTIVE SUBSTANCES IN CERTAIN WOODS ON THE DURABILITY OF PAINT COATINGS, *F. L. Browne.* U. S. Dept. Agr., Forest Serv., Forest Prod. Lab., 1935, pp. 7, figs. 2. Tests to determine the effect of extractive substances in certain woods on the durability of paint coatings are reported.

The general plan of these tests was to transfer the characteristic extractive substances of ponderosa pine, redwood, and southern cypress to parts of boards of a softwood lacking in characteristic extractives of its own, and then to test the durability of coatings of paint applied to both the treated and untreated parts of the boards. The wood chosen for the test panels was eastern hemlock. Each test panel was 18 by 72 inches in size, made up of four boards of nominal 0.5 by 6-inch bevel siding. Each panel was marked off into three test areas each 18 by 24 inches, of which the center area was the control area of untreated hemlock for comparison and the left and right-hand areas were treated with extracts from other woods. After such treatment the entire panel was then painted with three coats of one of the paints and was exposed on a test fence in the vertical position facing south to observe the relative durability of the coating over the three test areas.

Four paints were used. The extract of ponderosa pine made pure white lead paint slightly more durable at Madison, Wis., and Fresno, Calif., and exerted no noticeable effect at the other stations, while it impaired the durability of lead and zinc paint at Madison, Fargo, N. Dak., and Fresno, exerting no noticeable effect at Tucson, Ariz., and Washington, D. C. The evidence, therefore, is consistent with the view that the resin in the pines is responsible for the lower durability of paints containing zinc oxide on the pines as compared with the durability on softwoods of similar physical structure other than pines.

The extract of redwood improved the durability of white lead paint at Madison, Fargo, and Fresno and that of lead and zinc paint at Madison, Fargo, Tucson, and Washington, exerting no effects at the other stations. The fact that redwood holds paint longer than other softwoods of similar physical structure may therefore be attributed to a beneficial effect of some of the extractive substances present in redwood.

The extract of cypress improved the durability of white lead paint at Madison, Fargo, and Fresno, and exerted no effect at the other stations. It impaired the durability of lead and zinc paint at Madison, Fargo, Tucson, and Fresno, but improved the durability at Washington. The evidence is in line with expectations as far as white lead paint is concerned but is anomalous in the case of lead and zinc paint.

The antagonistic effect of piny resin on paints containing zinc oxide was attributed to reaction between zinc oxide and the acids of rosin with resulting increase in the brittleness of the coating.

The paints dried as rapidly on the areas treated with the extracts as they did on the untreated control areas. On untreated hemlock and on hemlock treated with the extract of ponderosa pine the paints required only a few hours longer to dry than they did when applied to wood at approximately 11 per cent moisture content and in a reasonably dry atmosphere. On hemlock treated with the extracts from redwood and cypress the priming-coat paints remained liquid for several days and the drying of subsequent coats was retarded very materially. Transfer of the extracts of redwood and cypress to hemlock therefore made the hemlock just like redwood and cypress lumber with respect to the drying of paint.

RECENT RESULTS OF ENGINEERING EXPERIMENTS IN SOIL AND WATER CONSERVATION AT THE SOIL EROSION EXPERIMENT STATION, TYLER, TEXAS, *R. W. Baird.* 6. Southwest Soil and Water Conserv. Conf. Tyler, Tex., 1935, Proc., pp. 16-20. Data on runoff and soil losses from field areas with different characteristics and from different types of terraces, on erosion control in terrace outlet ditches and gullies, and on the use of farm machinery on terraced land are summarized.

For three terraces 1,700 feet long, with a uniform grade of 3 inches per 100 feet and with vertical spacings of 5, 4, and 3 feet, the soil losses have been 6.95, 6.46, and 4.20 tons per acre per year, respectively, for a 4-year period. Short terraces (700 feet) with spacings of 3, 4, and 6 feet show similar results, the soil losses for a 2.5-year period being 5.38, 6.54, and 7.24 tons per acre per year, respectively. Results for 4 years have definitely shown that there are excessive soil losses from terraces with grades of 6 inches per 100 feet.

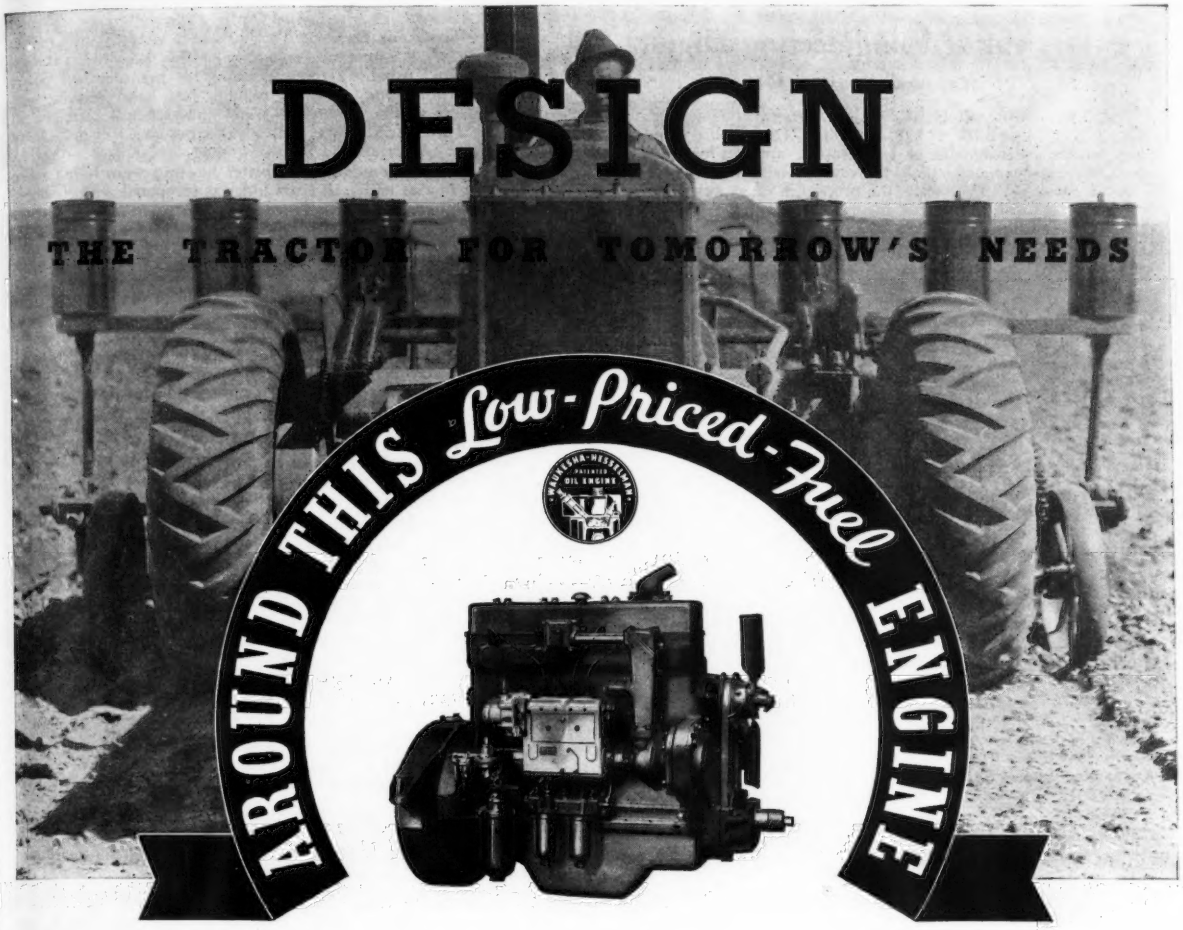
For long terraces (1,700 feet), a terrace with a variable grade of 0—3 inches per 100 feet has had a soil loss of 6 tons per acre per year, while a similar terrace with a uniform grade of 3 inches per 100 feet has had a soil loss of 6.95 tons per acre per year. The terrace with the uniform grade has also had the greater amount of runoff. Very long terraces with grades of 3 inches per 100 feet do not seem to be desirable. For 4 years a terrace 1,700 feet long has had 1.19 times as much soil loss as a similar terrace 700 feet long. However, the average runoff from the short terrace has been 10.22 inches per year and 7.95 inches per year from the long terrace. The runoff from this short terrace is consistently high, probably due to local field conditions, but from results for other graded terraces there is appreciably greater runoff from the short terraces.

There is a very marked difference in the maximum rate of runoff that may be expected from different areas and from different types of terraces. The most striking difference is between woodland and an unterraced, gullied, cultivated area which is quite similar. For a 3.5-year period the maximum rate of runoff from the wooded area has been only 0.31 inch per hour, while from the cultivated area a maximum rate of 4.46 inches per hour was obtained for one rain.

The effect of different types of terraces on the maximum rate of runoff is more consistent than on either the total runoff or on the amount of soil loss. The effect of the length of terraces is also quite marked, the maximum rate of runoff decreasing as the length increases.

VINE-MESQUITE FOR EROSION CONTROL ON SOUTHWESTERN RANGES, *B. A. Hendricks.* U. S. Dept. Agr. Leaflet 114 (1936), pp. 8, figs. 4. Practical information on the subject is presented.

A SUMMARY OF THE RECENT RESULTS OF ENGINEERING EXPERIMENTS IN SOIL AND WATER CONSERVATION AT THE BLACKLAND SOIL EROSION EXPERIMENT STATION, TEMPLE, TEXAS, *P. L. Hopkins.* 6. Southwest Soil and Water Conserv. Conf. Tyler, Tex. 1935, Proc., pp. 24-27. Date on erosion control as influenced by terrace design, construction, and maintenance are summarized. They show that soil losses increase with an increase of vertical interval on cultivated land but that other factors are important. It is apparent that a vertical interval of 3 feet is best for slopes of from 3 to 5 per cent on the black land. *(Continued on page 406)*



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WAUKESHA ENGINES

Agricultural Engineering Digest

(Continued from page 404)

A TEXT BOOK ON HEAT, *A. W. Barton*. Longmans, Green & Co., [1934], pp. XIII + 378, figs. 110. This book contains chapters on the measurement of temperature, specific heat and latent heat, the expansion of solids, the expansion of liquids, the expansion of gases, change of state, the properties of vapors, the dynamical theory of heat, the kinetic theory of gases, the relation between the liquid and gaseous states, Van der Waals' equation and the liquefaction of gases, cyclical operations and adiabatic changes, the second law of thermodynamics, conduction, and radiation.

FACTORS THAT INFLUENCE THE DECAY OF UNTREATED WOOD IN SERVICE AND COMPARATIVE DECAY RESISTANCE OF DIFFERENT SPECIES, *G. M. Hunt*. U. S. Dept. Agr., Forest Serv., Forest Prod. Lab., 1935, rev., pp. 5. The heartwood of catalpas, practically all of the cedars, chestnut, southern cypress, the junipers, black locust, red mulberry, Osage-orange, redwood, black walnut, and Pacific yew are classed as durable even under conditions that favor decay. Similarly the heartwood of aspen, basswood, cottonwood, the true firs (not Douglas fir), and the willows, when used under conditions that favor decay, may be classed as low in decay resistance; while the heartwood of Douglas fir, red gum, western larch, chestnut oak, southern yellow pine, and tamarack may be classed as intermediate. The heartwood of dense Douglas fir, honey locust, white oak, and dense southern pine may also be classed as intermediate, but nearly as durable as some of the species named in the high durability group. The heartwood of the ashes, beech, the birches, the hemlocks, sugar maple, the red oaks, and the spruces may be considered on the border line between the intermediate and nondurable groups and cannot with assurance be placed in either group.

NORTH CAROLINA FARM HOUSING, *E. W. Stevens* and *H. Estabrook*. North Carolina Sta. Bul. 301 (1935), pp. 82, figs. 10. The results of a study made by the station in cooperation with the North Carolina Department of Agriculture are presented which involved a house to house survey of 28,205 farm houses in 10 areas of the State selected to cover all types of farm life.

It was found that 95 per cent of all farmhouses were frame. Only 36 per cent of all farmhouses have even been painted, and only 7.3 per cent have paint in good repair. Seventy per cent are one-story.

The condition of 11 structural items was rated by the enumerators as good, fair, or poor. Fifty-two per cent of all houses had no screens, 17 per cent had poor screens, 18 per cent fair, and only 13 per cent had good screens. Percentages of other items rated good came to 28 per cent of all foundations, 24 of all doors and windows, 33 of all roofs, 24 of all floors, and 17 per cent of interior walls and ceilings. Only 2.5 per cent of the houses were listed as having any kind of insulation. Enumerators judged the following percentages of houses to be unfit for human habitation. In these houses cost of repair would be greater than cost of replacement: 4 per cent of the houses occupied by white owners, 5.5 occupied by white tenants, 7.2 occupied by negro owners, and 8.6 per cent occupied by negro tenants. Two-thirds of all North Carolina farmhouses have no provisions for storing fruits and vegetables.

Three-fourth of white owners had living rooms, but only half of the white tenants, half of the negro owners, and less than a third of the negro tenants. Somewhat lower percentages in each group had dining rooms. Over 40 per cent of all houses and over 30 per cent of white-owner houses had no closets.

Over three-fourths of all farm families surveyed carried their water, and only 11 per cent had a kitchen sink with drain. Half of the houses surveyed got their water from dug or bored wells, a fourth from drilled or driven wells, almost a fifth from springs, and only 0.2 per cent from cisterns. One hundred and eighty families were getting their water from streams, and 213 had no source of water on the premises. One out of 5 wells needed repairs and 1 out of 7 should be abandoned.

Over half of all families were using unimproved privies, 11 per cent were using improved privies, 3 per cent were using flush toilets, and 0.1 per cent chemical toilets. A full third of all farm families were found with no toilet facilities whatever. Among white owners, 27 per cent had no toilet facilities. Of all the families, 5.8 per cent had bathrooms, 3.2 per cent had bath tubs, and 3 per cent had lavatories.

The number of families with labor-saving conveniences was very small. A total of 9.5 per cent of all families had electric lights; 17.8 per cent of white owners. Less than 2 per cent of all families and less than 3 per cent of white owners had either a circulating heater or furnace. Only 7.4 per cent of all families had some kind of improved cook stove, either kerosene, gasoline, gas, or electric, usually kerosene; while 1.8 per cent had power washing machines and an equal number had hand washing machines. Most of the laundry is done outdoors. A fifth of all families had ice refrigerators, and only 1.1 per cent had mechanical refrigerators, 2.5 per cent of white owners.

Few significant trends toward better housing were found when a sample of houses under 10 years old was compared with a sample from 25 to 49 years old.

PACIFIC NORTHWEST SOIL EROSION AND MOISTURE CONSERVATION EXPERIMENT STATION, *C. E. Deardorff*, et al. Washington Sta. Bul. 325 (1935), pp. 68-74. The progress results are briefly presented of experiments on vegetative control of erosion, terracing, tillage for erosion control, gully control, forage crops and mixtures of grasses and legumes for erosion control, wind erosion, soil moisture, strip cropping, soil building rotations for erosion control, and utilization of clay points by planting to timber cover. This work is cooperative with the USDA Soil Conservation Service.

RURAL ELECTRIFICATION, *J. P. Schaenzer*. New York: Bruce Publishing Co., 1935, pp. IX + 266, figs. [169]. This is a popular treatise on the subject, based largely on the author's experience as project director of the rural electrification research and educational program conducted by the University of Wisconsin.

It contains chapters on electricity the silent partner, how electricity is made and distributed, serving the farm customer, wiring materials, wiring maintenance and repair, wiring the farmstead, wiring the home, wiring the barn and outbuildings, lights and lighting, farm electric lighting plants, electric motors, fractional-horsepower motor applications, ensilage cutters, feed grinders, wood sawing, hay hoisting and baling, farm water supply, poultry house lighting, the electric incubator and brooder, the milking machine and cream separator, dairy refrigeration, other electrical equipment for the dairy, the electric hotbed, laundry and cleaning equipment, and kitchen and household equipment.

TEMPERATURE STRESSES IN CHIMNEYS AND TANKS, *H. Carpenter*. Concrete and Construct. Engin., 31 (1936), No. 2, pp. 105-113, figs. 9. A technical analysis of these stresses is presented.

FARM WATER SUPPLY EQUIPMENT, *C. A. Cameron Brown*. Jour. Min. Agr. (Gt. Brit.), 42 (1935), No. 4, pp. 319-325. In a contribution from the Institute for Research in Agricultural Engineering at Oxford University techinical information is presented on the subject.

BOX TESTING EQUIPMENT. Jour. Min. Agr. (Gt. Brit.), 42 (1935), No. 4, pp. 316-318, pl. 1. Equipment for testing packing cases, wooden boxes, and fiber containers, by stresses similar to those experienced in road and rail transport, is described as installed at the Forest Products Research Laboratory in England.

The equipment provides for endurance and strength tests of the boxes and of the material employed in their construction. The principal endurance test is furnished by a large rotating drum, 8 feet in diameter, revolving twice a minute. The box to be tested is placed in the drum, which can take cases of a size up to a 2-foot cube. As the drum revolves, wooden baffles on its inner face catch the box under test and roll it over, so that it falls on its edges, corners, and faces, in turn. A moderately well-made wooden container has been found to open up after about 30 falls, but one really well-designed has withstood 150 or more falls. In this manner the hazards of modern transport are simulated, and a technic has been developed by which the stability of packing cases of new design can be compared with those whose strength has been established under actual use.

The resistance of a case to more drastic treatment is tested by a "dropping" machine, in which the case is made to fall from a height on to a steel plate. This machine is also designed so that the case can be dropped on a face, corner, or edge, at will.

A third piece of testing equipment is a crushing machine, by which compressive stresses can be applied to the opposite faces or corners of the box. This determines the resistance of the container to crushing when stacked in storage or during transit, and is of particular value for testing fiberboard containers, their rigidity during storage being of special importance. The utility of the machine was shown in some preliminary experiments on the strengthening of a wooden packing case by the addition of wooden battens. One type of case opened up under a pressure of 550 pounds applied at the ends. When, however, battens were put around the ends, it withstood a pressure of 1,000 pounds, and with the further addition of battens around the four sides the case did not give way until a pressure of 2,000 pounds had been reached.

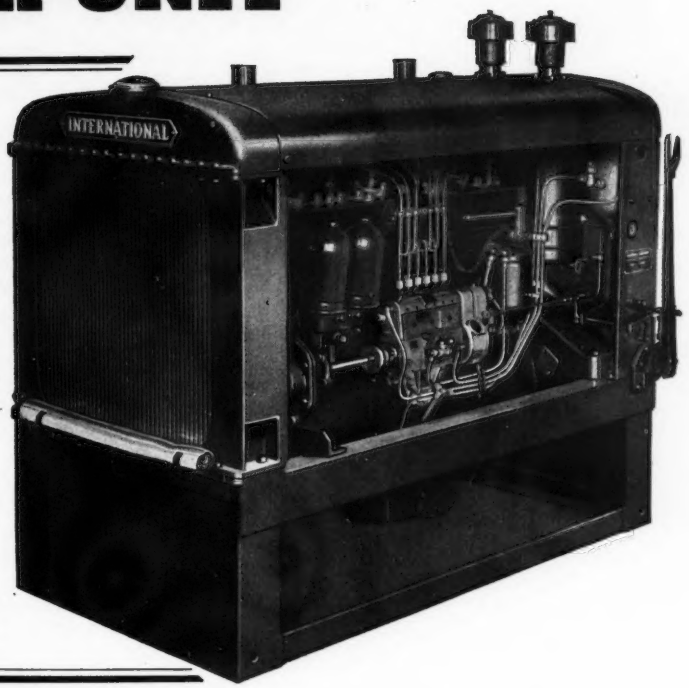
(Continued on page 408)

The *NEW* INTERNATIONAL PD-80 POWER UNIT

SPECIFICATIONS

Maximum Horsepower (corrected to sea level barometric pressure and 60 F — power unit fully equipped)	100
Horsepower, Continuous Load (80% or Maximum Horsepower)	80
Number of Cylinders	6
Bore and Stroke, inches	4¾ x 6½
R.P.M.	1400
Clutch Diameter, inches	15
Clutch Torque, pound-feet	785
Flywheel Housing	S.A.E. No. 1
Fuel Used	Diesel Fuel
*Belt Pulley Diameter, inches	12
*Belt Pulley Face, inches	13
*Belt Speed, feet per minute	4398
Overall Length, inches (including starting crank but not belt pulley)	98¼
Overall Width, inches (24-inch turning radius of starting crank not included	41
Overall Height on welded steel base, inches	66¼
Approximate Weight, fully equipped, including welded steel base, pounds	3750

*Belt pulley is special equipment—other sizes available.



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The new International PD-80 starts as a conventional gasoline engine and is as easy to start as any gasoline engine of its size. After the engine has warmed up for two or three minutes the operator easily converts it to full Diesel operation by turning a conveniently placed crank one-quarter turn. Even in the coldest weather the engine parts are thoroughly warmed during this starting period, assuring full heat from compression to give a snappy. Diesel start and efficient Diesel operation.

The new Model PD-80 is the latest addition to a line of power units ranging in size from 12 h.p. to 100 h.p.—all built to the traditional International Harvester standard of quality and backed by a nationwide network of dealers and direct-factory branches. The International Harvester power line also includes TracTracTors (crawlers) in three sizes and Wheel Tractors for all kinds of work. Check your power requirements with the nearest branch or dealer, or we will send complete information on request.

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Agricultural Engineering Digest

(Continued from page 406)

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE MARYLAND STATION. Maryland Sta. Rpt. 1934, pp. X-XII. The progress results are briefly presented of investigations on small electric milk pasteurizer, electric soil sterilization, mushroom culture in electric hotbeds, temperature control in electric hotbeds, electric fruit and vegetable drier, and farm use of fractional horsepower electric motors.

CORROSION-PROTECTIVE VALUE OF ELECTRODEPOSITED ZINC AND CADMIUM COATINGS ON STEEL, *W. Blum, P. W. C. Strausser,* and *A. Brenner.* Jour. Res. Natl. Bur. Standards (U.S.), 16 (1936), No. 2, pp. 185-212, figs. 8. Atmospheric exposure of plated specimens in six locations showed that in a rural or purely marine climate both zinc and cadmium coatings furnished better protection against the corrosion of steel than did nickel or chromium coatings of the same thickness, although the zinc and cadmium rapidly lost their luster. In an industrial atmosphere where sulfurous and sulfuric acids are present both zinc and cadmium were attacked rather rapidly and the life was about proportional to the thickness. Under these conditions the cadmium coatings failed in about two-thirds of the time required for failure of zinc coatings of the same thickness. Zinc-cadmium alloys containing about 10 per cent of cadmium were superior to either zinc or cadmium. Variations in the conditions selected for depositing the coatings did not have a marked effect on their protective value. Hot-dipped zinc coatings gave about the same protection as plated zinc coatings of the same thickness.

In accelerated tests, such as the salt spray or intermittent immersion in a solution of sodium chloride, the time required for failure of a zinc coating is about proportional to its thickness. Cadmium coatings last much longer than those of zinc in a salt spray, which is not, therefore, a true measure of their relative value in an industrial atmosphere.

The protective value of a zinc or cadmium coating depends principally upon its minimum thickness, which can be determined by dropping tests, microscopic measurements, and the chord method.

CARE AND REPAIR OF MOWERS AND BINDERS, *W. R. Humphries.* U. S. Dept. Agr., Farmers' Bul. 1754 (1936), pp. II + 21, figs. 10. This bulletin is a revision of and supersedes Farmers' Bulletin 947. It contains practical information on how to make needed repairs and adjustments in mowers and binders.

ELECTRICITY IN THE HOME AND ON THE FARM, *F. B. Wright.* New York: John Wiley & Sons; London: Chapman & Hall, 1935, pp. XIX + 320, figs. [234]. This book is based on the author's work at Cornell University and is written for those who wish to gain a practical knowledge of electricity and its application in the home and on the farm. The book is divided into two parts.

Part 1 contains sections on electric circuits; the dry cell; doorbell circuits; switches; electric fuses; conductors and insulators; how to figure wire sizes for a given load; splicing conductors; extension cords; lamp sockets; trouble lamps; watt-hour meters; wiring systems for light, heat, and power; installing outlets; special circuits; transformers; electric motors; electric generators; electric heating appliances; and storage batteries.

Part 2 contains chapters on the nature of electricity, direct-current circuits, electrical terms and measurement, magnetism, electrical effects, electro-magnetic induction and some of its applications, direct-current generators and motors, alternating currents, power transmission and distribution systems for alternating current, and alternating-current generators and motors.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE TEXAS STATION, *R. E. Dickson, B. C. Langley, D. Scoates, H. P. Smith, D. T. Killough, D. L. Jones, M. H. Byrom, B. H. Hendrickson, R. W. Baird, E. B. Deeter,* and *P. L. Hopkins.* Texas Sta. Rpt. 1934, pp. 59, 60, 128, 129, 147-153, 175-178, 188-190. The progress results are briefly presented of investigations on runoff losses in relation to crop production and soil erosion, mechanical harvesting of cotton, and soil erosion investigations at Tyler, Temple, and Spur.

AN INTRODUCTION TO STRUCTURAL THEORY AND DESIGN, *H. Sutherland* and *H. L. Bowman.* New York: John Wiley & Sons. London: Chapman & Hall, 1935, 2. ed., pp. XI + 318, figs. 189. This is the second edition of this book in which a more complete presentation of the basic elements of these methods is made.

The section on moment distribution has been rewritten, presenting a new statement of the principles involved, with a consideration of one-story structures transversely loaded. It has become evident that the most efficient of all methods for the analysis of secondary stresses is moment distribution, and a complete statement of this application of the method has been added. Also, a section has been added describing the column analogy, a simple method of dealing with arches, tunnel rings, and single-span structures with end restraint.

A Method of Measuring Acres per Mile of Terrace and Total Acres Benefited

(Continued from page 395)

$[(n + 1) \times L \div 5280] \times C$, where L is average length of terrace and the other notations the same as previously used.

Table 2 gives the values for that part of the equation in brackets for any number of terraces from 1 to 15 and average lengths of from 200 to 1600 feet. The table may be readily expanded for a larger number of terraces and for other lengths but seldom are there more than 15 terraces in parallel and more than 1600 feet in average length. The table may be interpolated with sufficient accuracy for intermediate lengths.

Thus, to find the actual area controlled by any number of terraces in a field or single terrace system, multiply C (selected from Table 1 for average spacing) by the factor from Table 2 for the number and average length of terraces.

This gives a ready and convenient means of determining the area controlled or benefited by terracing, by making two simple measurements. First the total length of terraces, which is frequently available from the layout notes, and from which the average length can be determined. Second, the average spacing which on irregular contour may have to be secured by pacing or measuring at several points and taking the average. But even allowing for some inaccuracy and inconvenience in securing these measurements, it is believed the results are more accurate and much more easily secured than by any other method of field measurement.

No method other than direct-area measurement has been suggested as yet to determine the acreage on which terracing benefit payments are to be made in the agricultural conservation program. This plan or some adaptation of it should prove practical for this purpose as well as for any other use where area controlled is necessary for reports or other purposes.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL ENGINEER, farm reared, with B. Sc. in agricultural education from Montana State College and M. Sc. from Iowa State College, major in vocational education and minor in agricultural engineering. Graduate work in agricultural engineering at Iowa State College, practically equivalent to B. Sc. degree. Eleven years of teaching experience, five years in high school vocational agriculture and five years in farm mechanics in the agricultural engineering department at Iowa State College. Two and one-half years experience in soil conservation work in ECW and the Soil Conservation Service. Also some sales experience. Desires teaching, extension service or related work in agricultural engineering. Especially interested in farm machinery and soil conservation work. Age 38. Married. PW-273